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THE NEW YORK TRADE SCHOOLS.

THE New York Trade Schools, located on First Avenue, Sixty-seventh and Sixty-eighth Streets, were established nine years ago, for the purpose of giving young men instruction in certain trades, and to enable young men already in those trades to improve themselves.

Instruction in the mechanic arts, other than that which could be had in a workshop, was regarded in this country as of little promise when the New York Trade Schools were established. The value of such instruction has now been proved, and there has hardly been a convention of master mechanics, during the past two years, at which the necessity of more systematic instruction in the trades than can be given in a workshop has not been admitted. This result has been brought about by the thoroughness of the instruction, both manual and scientific, which the New York Trade Schools have shown a trade school can give.

The New York Trade Schools are conducted on the principle of teaching thoroughly how work should be done, and leaving the quickness which is required of a first class mechanic to be acquired at real work after leaving the schools. Progress at a trade school is necessarily rapid, as it is constantly sought to ascertain not only what the pupil knows, but in what he is deficient. Such a system can rarely be pursued in a workshop, where each employe is necessarily employed upon the work he can do best. Experience has shown that from one-third to one-half a day's work can be done after one season's course of instruction, and that from one-third to one-half a day's wages can be obtained. Full wages have usually been obtained in from six months to two years after leaving the New York Trade Schools, according to the nature of the trade. Young men who were exceptionally quick at learning have obtained full wages at once; but it is the opinion of the management that steady work at moderate wages is the more profitable in the end.

Instruction in the mechanic arts is not a new thing. In Europe schools have long been in existence for the building trades, for workers in wood, metal, and leather, for weaving and dyeing, for furniture makers, wood carvers, watch makers, brewers, etc. Some of these schools, like the Imperial Technical School at Moscow, and the schools at Crefeld and Chemnitz in Germany, at Verviers in Belgium, the Trade Schools in Paris, and the London Guilds School, are on a magnificent scale. Instruction is provided by these foreign schools both for young men already in the trades and for beginners. In the United States the Master Plumbers' Associations in some of the cities provide instruction for their "helpers." The Carriage Makers' Association has a school in New York for the young men employed in carriage building, and a number of private firms provide instruction for their employes. Trades are taught to beginners at the Pratt Institute in Brooklyn, at the Free Institute, Worcester, Mass., and at some of the colleges endowed by the United States land grant act. Trades are taught to colored young men at Hampton, Va., at Clark University, Atlanta, Ga., and at Central Tennessee College; to Indians at Carlisle Barracks, Pa.; and to young men in many asylums and reformatories. In both the American and foreign schools where trades are taught to beginners, the trade instruction is usually combined with a general instruction extending over several years. This system of combining trade instruction with a general education does not meet the wants of young men who must support themselves or contribute to the family support. The system of trade instruction which seems best adapted to American wants is to leave the general education to the public schools and confine the work of a trade school to the manual and scientific instruction necessary to make a mechanic.

On this system the New York Trade Schools have been conducted, and the Mechanical Trade School of the Builders' Exchange, of Philadelphia, is to be conducted on the same plan.

The New York Trade Schools have obtained their reputation by the system of trade instruction originated by Mr. Auchmuty, the proprietor, in which both the manual and scientific branches of a trade are so arranged that not only can skill be quickly acquired, but the reason why work should be done in a certain way is made plain. This system differs from anything heretofore attempted in trade instruction. It has produced remarkable results and has attracted much attention both in this country and in Europe.

For each of the trades taught at the New York Trade Schools, a course of instruction has been prepared by which the pupil is first taught simple work, and then is put upon that which is difficult and complicated, until he is made familiar with the various branches of his trade. In the preparation of these courses of instruction, technical books and trade papers were studied and the advice of master mechanics of reputation was obtained. A careful record has also been kept each year of the progress of the young men, and the courses of instruction have been modified at different times to overcome difficulties which arose, until now, at the commencement of the tenth season, it can safely be said that the purpose for which the system followed at the New York Trade Schools was devised has been accomplished, viz., to enable young men to learn the science and practice of certain trades thoroughly, expeditiously and economically, leaving speed of execution to be acquired at real work after leaving the schools.

For the manual instruction skilled mechanics are employed as teachers, who show the pupil how to hold his tools, how to stand, how each kind of work should be done, and who see that it is done correctly.

The scientific instruction is given by means of lectures, by hand books arranged with questions and answers, and by diagrams illustrating not only how work should be done, but the difference between good and improper work.

In the bricklaying classes the young men are taught first how to handle the trowel and how to spread mortar. After this they are practiced on eight and twelve inch walls. When these can be carried up plumb and the courses laid level, the class is put upon walls returned at right angles, piers, arches, fire places and flues. Great care is exercised that each brick is properly laid, and that the joints are neatly pointed. No attempt is made to work fast until toward the close of the course, when an hour is given at stated intervals, to ascertain how many bricks each member of the class can lay in that time in a workmanlike manner on a straight wall. The brick work is carried up as high as the young men can conveniently work; it is then torn down and the bricks cleaned, to be used again. Before an exercise is commenced, the instructors show how it should be done. The young men are then required to practice under the constant supervision of the instructors until they can do the work well.

Members of the school, after finishing their course of instruction, were employed to build three stores on 125th Street, near 5th Avenue, also to build the large apartment house on the corner of 93d Street and 9th Avenue. Members also built four houses on 68th Street, between 1st and 2d Avenues. Five houses on 68th Street were built by members. Five houses on 69th Street were built by members. A calculation was made of the number of brick laid each fortnight, and the young mens wages were graded accordingly. Nearly all the brick of these buildings, except the face brick, were laid by young men who could not handle a trowel when they joined the schools six months before being employed. Much of the face brick on the buildings erected the last three seasons has been done by former graduates of the schools. It would be difficult to find more thorough or better work. The lines are true, each joint is straight and neatly struck. The work looks as though the builders had "put their hearts in it." The Philadelphia Builders' Exchange sent a committee to inspect these buildings and the work on exhibition at the New York Trade Schools. So favorable a report was made that it was decided to establish the Mechanical Trade Schools of the Philadelphia Builders' Exchange.

To strong, active young men, old enough to do a day's work, this bricklaying class offers an opportunity to acquire speedily and at a small cost one of the most profitable trades in the United States.

The plastering room is divided into compartments measuring eight by ten feet and nine feet high, the walls and ceilings being lathed in the usual manner. Two young men work in each compartment. They are taught first how to apply the "scratch coat" on the walls and ceilings. This coat is taken off by laborers after each evening's work, leaving the laths ready for the young men on the following evening. The class is exercised on this work until it can be done neatly and rapidly. The "scratch coat" is then allowed to harden and the young men are shown how to apply the "brown coat." This coat is also removed after the work is finished. Then follows hard finishing and the running of plain cornices. The illustration shows the arrangement of the plastering room and the method of instruction.

The skill that can be acquired in the plastering class can be seen by the plaster work now on exhibition at the schools, but the best proof of what is learned in class is the success that has attended its members; full wages being frequently earned on leaving the school. Young men now in the bricklaying trade would do well to take this course in plastering, as the trades are combined in country towns.

The plumbing classes are under the supervision of the Trade School Committee of the Master Plumbers' Association of New York.

At the termination of the course of instruction, the Trade School Committee of the Master Plumbers' Association examines the members of the plumbing classes to ascertain their manual skill and scientific knowledge.

Certificates are given to those entitled to receive

PLUMBING SHOP AT THE NEW YORK TRADE SCHOOLS.

them, which will be found valuable in seeking for work.

The possession of a certificate will reduce the term for which "helpers" are usually employed in New York by one year.

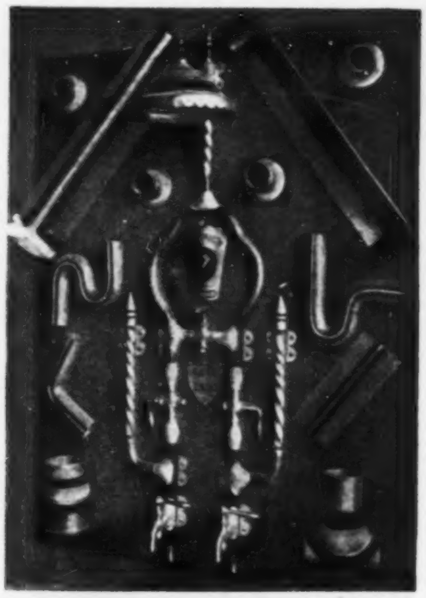
The plumbing classes at the New York Trade Schools have earned a high reputation. The system on which they are conducted has been followed in the plumbing schools now established in various parts of the United States and at the plumbing school in Montreal. The plumbing shop at the New York Trade Schools is thirty feet wide by seventy feet long, and is fitted up with all the appliances of a first class shop. Each young man is furnished with a set of tools and has his allotted place at the work bench. The instructors, who are skilled mechanics, follow a regular course. Each member of the class is shown how his work should be done, and it is the duty of the instructor to see that it is done neatly and in workmanlike manner. The solder is melted by means of Bunsen burners, supplied with gas. This avoids the heat and unwholesome gases of charcoal, or the danger which might arise from a great number of gasoline furnaces. Each member of the class is advanced as rapidly as his proficiency will allow. He is provided with a separate compartment, in which the specimens of his work are kept after being approved of by the instructor. These specimens can be taken away at the end of the course by paying for the cost of the material used. Great care has been bestowed on the scientific course of instruction.

For each of the subjects, printed forms are furnished containing questions with blanks left for the answers. The lecturer reads the question and writes the answer to it on the blackboard. This answer is copied by the young men in the blank space in the printed forms. The lecturer then proceeds to explain fully what is meant, to illustrate his meaning by diagrams, and to answer questions put by members of the class. The printed forms, after being filled up, are kept by the young men for future reference. Diagrams are also given the members of the class of improperly arranged plumbing, many of them taken from faulty work that has actually been done in this city, which they are required to correct. By this course of manual and theoretical instruction, a knowledge of the trade is acquired which it would be difficult to obtain in any other way. Young men in the trade, and those who propose to enter it, should remember that the plumber, if he is to succeed, must know far more than was required of him a few years ago.

PLASTERING ROOM AT THE NEW YORK TRADE SCHOOLS.

PAINTING ROOM AT THE NEW YORK TRADE SCHOOLS.

The skill that can be acquired in both the day and evening classes can best be determined by examining the specimens of work now on exhibition at the schools, some of which were done by "helpers" and some by young men who had no knowledge of the trade when they joined the plumbing class.



HENRY T. BUESCHE OF KANSAS CITY, KANSAS.

Besides the regular course of instruction given to both day and evening plumbing classes, the members of the day class are instructed in the best method of keeping plumbers' books and in mechanical drawing. The young men are taken over different buildings, and the system of plumbing followed in New York explained to them. Visits are also made to the show rooms of prominent dealers in plumbers' supplies. The members of this class are required to fill up specifications for an ordinary city house, according to the rules of the Board of Health of the City of New York.

We give engravings of some of the specimens of plumbing work.

The young men in the carpentry class are shown the use of the various tools commonly used in the trade, great care being taken that each is held and used in a workmanlike manner. After this has been acquired and boards can be sawed to a line and neatly planed, mortising and tenoning are taught. Then panels are framed, mouldings are put on, and later doors and shutters are made. Partitions are also set, floors and partitions are bridged, and flooring laid. A small frame house is also framed, sheathed, shingled, etc. This course of instruction gives each member of the class a varied amount of work.

The scientific instruction includes the meaning of the terms used in carpentry, laying out a building from a plan, the framing of partitions and roof trusses, strength of girders, etc.

FRANK H. HYDE, OF BENNINGTON, VT.

The painting classes are under the supervision of the Trade School committee of the Master Painters' and Decorators' Society of New York, John Beattie, H. D. Moeller, Theodore C. Johansmeyer, T. L. Taylor and Joseph Scott, who give certificates to those entitled to receive them.

Young men by this course of instruction in painting can prepare themselves to enter an excellent trade, and one for which there are openings for those who know how to work, in every town in the United States. The courses of instruction, which combine both the science and practice of the trade, are arranged for those who are now employed in shops or who desire to enter the

trade. The committee of the Master Painters' and Decorators' Association recommend these classes to well educated young men who are old enough to know for what sort of work they are fitted, as the instruction should enable them to make their labor of value, and in a reasonable time after leaving the schools to become journeymen.

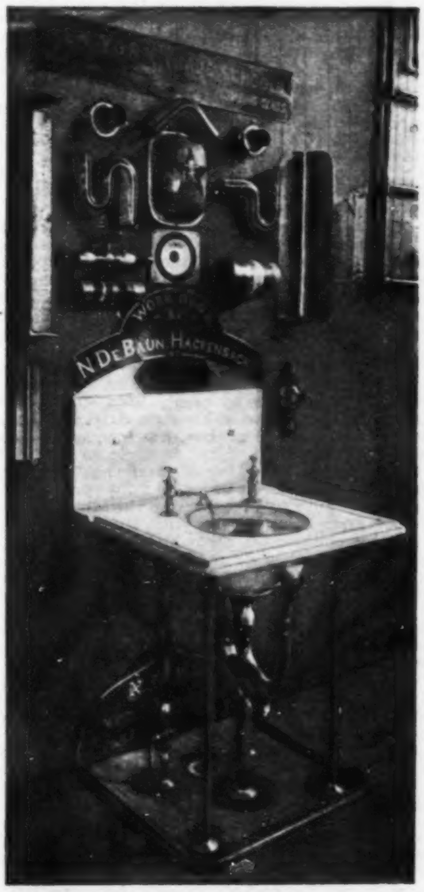
There is a large wall surface in the school buildings on which the young men are practiced, and wooden screens fitted with doors, windows, box shutters, etc., are used for instruction in fine work. Some of the compartments shown in the photo-engravings contain specimens of fancy painting, lining, gilding, graining, work in flat colors and polish white, executed by young men who had no previous knowledge of the trade when they came to the schools, which would do credit to any journeyman.

The manual instruction commences with preparing the surface for painting, mixing paints, care of brushes and paint pots, plain painting, etc. When the pupil can cover plain surfaces of wood, brick or tin in a satisfactory manner, and can explain where to begin his work, he is exercised in painting in colors, in flatting, polish white, stippling, gilding, and glazing.

In mixing paints, samples of various colors are given, which the pupil is required to match.

The scientific instruction includes the harmony of colors, mixing of colors, properties of oils and driers, and the various materials used in painting, etc. Lectures are given by Mr. Joseph Scott, the young men being required to illustrate the subjects discussed by actual experiments.

The instruction in fresco painting is given in the evening, but a portion of the day is set apart for practice. The young men last season, after they had been six weeks at the schools, cleaned a large, badly discol-



NEWTON DeBAUN, HACKENSACK, N. J.

ored ceiling, cut out the cracks down to the laths, colored and stippled the plain surface, prepared the stencils, put on elaborate and beautifully executed ornament, and lined the edges as neatly as if done by a journeyman.

Instruction in sign painting has been given at the New York Trade Schools for two seasons. Rapid progress has been made by the members of this class and excellent work has been done, as can be seen by the collection of signs with plain and ornamental lettering, which are now on exhibition at the schools. A knowledge of sign painting is gained by this course of instruction, given by a first class sign painter, which could be obtained with difficulty even in the best shops. The course of instruction is arranged both for beginners and for those who have a knowledge of the trade. Skill in sign painting is particularly valuable to mechanics who find work in country towns.

The instruction in fresco painting consists in preparing walls and ceilings for kalsomine; in lining, to which particular attention is paid; in laying out work; in making pounce and stencil and applying same; in putting on flat and shaded ornaments, etc. The fresco painting is executed on plastered screens and on ceilings.

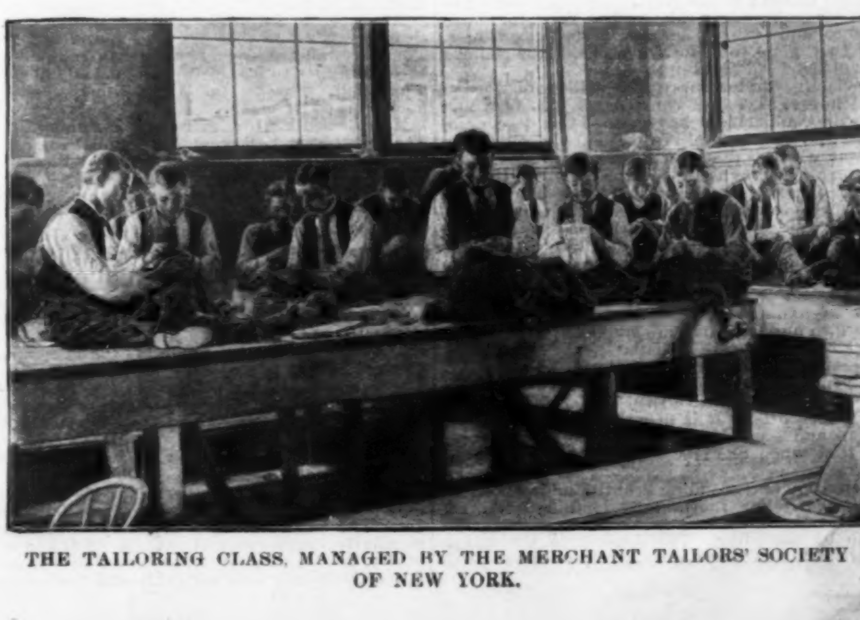
Fresco painting was one of the first trades taught at the New York Trade Schools, and excellent work has been done by those who have attended this class. The instruction is given by a practical fresco painter; the pupil, as in the other classes at the schools, being made to follow a systematic course. Toward the end of the season elaborate designs have been painted, which have been exhibited and received favorable comment at the fair of the American Institute and at the rooms of the Master Painters' and Decorators' Association of New York.

Attention is called to the photo-engravings of work done by members of this class during the last two sea-

PAINTED BY F. H. WARNECKE.

STONE CUTTING—SPECIMENS OF WORK AT THE NEW YORK TRADE SCHOOLS.

SPECIMENS OF WORK BY MEMBERS OF BLACKSMITH CLASS, NEW YORK TRADE SCHOOLS.



THE TAILORING CLASS, MANAGED BY THE MERCHANT TAILORS' SOCIETY OF NEW YORK.

sons, which, with much other work, can be seen by a visit to the schools. This work was done from the preparation of the walls and making the stencils to the finest work by the young men, without being touched up by the teachers.

In stone cutting the course of instruction commences with squaring an irregular block of stone. The pupil is then shown how to finish the surface in various ways, such as rubbed, tooled, bush hammered, random pointed, tooth chiseled, etc. He is then taught to cut chamfers, simple mouldings, return mouldings, raised and sunken panels.

It is difficult to realize how much more thoroughly and rapidly such a trade as stone cutting can be learned with a skilled mechanic to show how each piece of work should be done, and to explain why it should be done in a particular way, than by leaving the trade to be acquired by observation and by chance.

Instruction in plain and ornamental stone cutting in brownstone has been given at the New York Trade Schools on three evenings a week, for a number of years. The superb exhibit of cut stone in the stone cutting shop at the schools, which was done without assistance after one season's instruction, is proof of what can be learned.

The instruction in blacksmith's work covers the management of the fires, in drawing down, bending, shortening, welding, splitting, punching, chamfering, riveting, railing and house work. In vise work—instruction in filing to line, fitting tongues and grooves, chipping, bevels, scraping, ring work, drilling, etc. In tool making the instruction includes machine, lathe, millers', stone cutters', carpenters', plumbers', pipe and steam fitters', tin and coppersmiths' tools; also in the principles of tempering.

The blacksmith's shop is in charge of a practical mechanic, and is fitted up with forges and the tools and appliances of a first class shop. The growing demand for wrought iron work makes the instruction given at the New York Trade Schools particularly valuable. The work now on exhibition at the schools shows what neat and beautiful work can be done after one season's instruction.

The work required of the young men is hard, but the hours of instruction are not too long to render the practice more than good exercise. The members of this class are advised to keep a flannel shirt at the schools to work in, so that their clothing can be dry when they leave.

The tailoring class is managed by the Merchant Tailors' Society, of New York. The object of the Merchant Tailors' Society in establishing a school of tailoring is to teach the trade thoroughly in all its parts. The school is under the supervision of first class teachers, who are practical tailors and understand every detail of the trade.

When a pupil has finished his course of instruction and has passed his examination, he will receive a certificate of the Merchant Tailors' Society, testifying as to his proficiency.

There will be no allowance made to a pupil for any former knowledge of the trade which he may have obtained elsewhere.

In order to develop the pupil's physical condition, a course of gymnastic exercises is given by a competent professor.

To accommodate the young men who come to New York to attend the New York Trade Schools, the building No. 300 East Sixty-seventh Street has been erected, where comfortable, well furnished rooms are rented at two dollars per week for single rooms, and three dollars per week for double rooms with two beds. This includes lights and attendance. The building is within a few minutes walk of the Trade Schools, and is in charge of a respectable family. Meals can be had in neighboring houses and restaurants at from \$3 to \$3.50 per week.

THE RETSOF SALT MINES AT GREIGSVILLE, N. Y.

By S. L. Sheldon.

The Retsof salt mines are situated in the southern part of the town of York, Livingston County, N. Y.

The name under which the works are conducted is The Retsof Mining Co. This company was formed in New York City, under the able management of Mr. J. W. Foster, after whom it was named, the name of the mine being the word "Foster" spelled backward.

The great undertaking of channeling for salt was commenced in the fall of 1884. A whole million was expended to accomplish the work, which occupied about a year and a half. Now, however, these mines yield bountiful returns, being one of the best paying industries in the country.

Five hundred tons are taken out daily and sent to all parts of our Union; to the West, for salting cattle; to the East, for making soda ash; to New York, for statuary; and to many other places, for miscellaneous uses. The supply seems to be inexhaustible. It is claimed that it will last for a thousand years.

In the vicinity of the mines a whole village of wooden huts and houses have been constructed, also boarding houses, stores, and offices have turned the once desolate place into busy bustle. In the midst of all rises a huge tower, which is the head house or entrance to the mines, and also serves as an elevator by which the salt is conducted into great chutes and store houses. At the east of this tower are the boiler and engine rooms, where twelve boilers, with a capacity of nine hundred and sixty horse power, furnish the force to run the powerful machinery. To run the twenty foot drum on which the cable is wound requires three hundred horse power. To run the blower, crusher, air compressor, and electro-dynamo also requires powerful engine power. Two hundred men are employed about these mines. Most of these are Italians.

At present the mines are reached only by one shaft, although the second shaft is down about two hundred feet. This entrance is a vertical shaft, 16 by 20 feet and 1,185 feet deep. It is provided with two cages, drawn up and down by cables, and these are so arranged that when one is ascending, the other is descending.

The sensation of descending into the mines is somewhat peculiar. For the first five hundred feet the descent is natural, but for the remaining distance one seems to be ascending. The descent to the mines, which are about 1,085 feet deep, occupies about a half minute.

At present the mines are located in the upper stratum. There are two strata of salt, the first about nine feet thick, the second, separated by twelve feet of rock, is about sixty feet thick. Excavation is commenced at the top. Then, of course, when the second stratum is being worked, supports will be left at different points, so that there will be no danger.

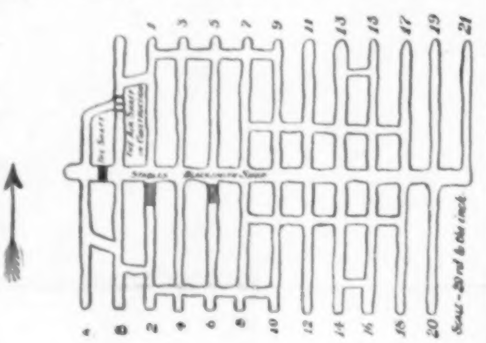
The mine, which has been worked about three years, presents mainly such an appearance as is seen in the diagram, except the representation of numerous cross cuts, now all the time being excavated. The cross cuts represented in the diagram are those through which the rail cars run.

The main gangway extends due east about a quarter of a mile. This is about nine feet high and from four to eight yards wide. Leading off on either side there are 25 chambers at right angles to the gangway, on the north 13, on the south 12. These chambers extend about 30 rods on either side the gangway and are nearly as large as the gangway. The chambers, as buildings of a city, are designated with even numbers on the one side and odd numbers on the other.

The shaft enters the mine at the west of the main gangway, while a little to the north there is an air shaft in construction. Situated in No. 2 are the mule stables, which can accommodate 15 or 20 mules. In No. 6 is the blacksmith's shop. As this stratum is undulating and slopes toward the west, so also does the mine. It is calculated that half as much salt will be left in the pillars as there is taken out, *i. e.*, one-third of the salt will be left for support.

The process of loosening the rock salt from its firm bed is accomplished by blasting. Holes made into the salt with air drills are filled with dynamite, which is exploded by electricity. Then the loose salt, on cars holding about four tons, is drawn to the shaft over a railroad by mules. At present eight mules are employed in hauling the salt. They are kept in the mine all the time, either in the stables or in the barnyard. Nearly one hundred men are employed in the mine, either as foremen, mule drivers, miners, or their assistants.

In the mine the air is quite pure. This condition is obtained by drawing out the foul air and forcing fresh air in. The air is dry as well as the mine, and has a chloric smell and a saline taste. The temperature is



A DIAGRAM OF THE INTERIOR OF THE MINE.

about 60° Fah. The most noticeable feature to a novice is its darkness and absolute stillness. It has a peculiar silence of its own. All disturbances, elemental and otherwise, which prevail in the open air are unknown and unfelt. The nervous person can there feel secure from the feeling of alarm which a thunder storm excites.

The miners use tallow candles to dispel the depressing darkness, the foremen, drivers, and shovelers use kerosene lamps, while the poor mules have to stumble around in the dark.

One of the strangest sights to a visitor is the blacksmith shop under ground. It is a very convenient and important feature of the mine, however, and Vulcan has a busy time indeed shoeing mules and sharpening the miners' drills.

The mine seems to be supplied with all modern conveniences. Among them is a telephone where one can converse with the superintendent above, an air whistle used as a signal for commencing and quitting work. There is also a system of pipes running to the different chambers which supplies the drills with compressed air.

The largest part of the salt taken out of the mines is of a dark gray color, and is claimed to be purer than that of a lighter color, being free of magnesia. Other portions of salt are of a reddish cast, while occasionally clear crystals the size of a man's hand are obtained. These crystals are found next to the rock, and are fastened so tightly to it that they are usually destroyed in separation. The crystal salt is chiefly found on the north side of the mine.

Mr. Edward F. Dibble, in a recent communication to *The Rural New-Yorker*, gives the following account of these mines. Of late years salt has been evaporated by steam heat to a great degree, and I think it safe to say that nine-tenths of all salt manufactured at present is made by this process. The idea of mining salt is a new one to Americans, although extensive salt mines have been in successful operation in different parts of England, Germany, Austria and Poland for long periods, and in one case in Galicia for seven or eight centuries. Six years ago Messrs. Varker & Freeman became interested in the recently opened Genesee Valley salt field, and put down a test well near Greigsville. The indications were so favorable that a company was formed for the purpose of sinking a shaft. As the work went forward the need of more capital was apparent, and a new stock corporation with a capital of \$3,600,000 was organized, known as the Retsof Salt and Mining Company.

The Retsof mine is located four miles northwest of Geneseo, in the town of York. The group of buildings form the nucleus of the village of Retsof, consisting of nearly 100 houses, with a store and meat market. The tall building is probably one of the most peculiarly constructed structures in the world, but utility, not beauty, is the watchword of the company. It stands directly over the shaft and rises above it to the height of 130 ft. The salt is raised to the top of this "head house," as it is called, and then runs through a series of iron crushers and sieves, the different grades running into separate bins in the warehouse as it descends. The buildings at the left, in reality part of the head house, are used as warehouses. They are fitted up with immense bins holding hundreds of tons of salt, which is loaded on the cars that run through the warehouse on three tracks. The ground floor of the warehouse at the extreme left is devoted to bagging and storing the finer grades, such as dairy, table, and common salt for household purposes. At the right is the engine and boiler house containing the motive power for the plant. There are two sets of boilers, each of 600 horse power, although only one set is used at a time. These generate steam for the large engine that drives the machinery, and also for the smaller engines that work the pumps and the dynamo, for all the buildings are illuminated by electricity. In the center of the engine room is a huge steel drum 14 ft. in diameter, on which is wound the wire cable that hauls the cages up from the mine. The company is now building a new warehouse 40 × 80 ft. and 65 ft. high, and expects to erect a new store and meat market in a short time. The works are about a mile from the Buffalo, New York and Philadelphia Railroad and are connected with it by a branch line owned by the firm. Two locomotives constitute the rolling stock. So much for a description of the surface, but interesting as the village of Retsof is with its busy whirl of business, the chief interest lies a thousand feet underground, literally down in the bowels of the earth.

The shaft connecting the surface with the mine proper is about 1,200 ft. deep, and before curbing was 13 × 19 ft. The curbing, which is made of heavy timbers securely mortised at the corners, has reduced the size to 12 × 18 ft. Up and down this shaft two cages run, on the principle of duplex well curbs, one rising while the other goes down. But what a difference! The cages are capable of carrying several tons and the rope is a heavy cable over an inch in diameter. Some people are rather timid about going down into the mine the first time, and the sensation one experiences is rather startling, to say the least. You enter one of the cages, the signal to descend is given, the engineer starts the mighty engine, the cable begins to unwind slowly, then faster and faster, and you drop, drop, 1,000 ft. in 1⅛ minute. As the cage nears the bottom the speed is slackened and it stops without a jar. As you step out and look around you cannot see much at first, for eyes accustomed to the sunlight do not readily adapt themselves to the dim, flickering light of mines. In a short time your eyes are all right, and you get an idea of what a salt mine really is. The men are at work in the first stratum of salt, which is about 15 ft. thick.

Twelve feet beneath is another one 60 ft. thick, and computations by statisticians prove that there is enough salt beneath the company's 600 acres to last 1,000 years at the present rate of mining. The main gangway is about nine feet high and from 12 to 24 ft. wide, and this, as well as the drifts, was blasted out of solid salt.

The salt is now being mined from the side drifts, of which there are some 25 or 30, and the process of mining is very similar to that used in the anthracite coal regions. First holes are drilled in the salt, with drills worked by compressed air which is forced from the surface and conveyed through iron pipes to the drills. Next dynamite cartridges are inserted into the orifices made by the drills, connection is made with the electric wires, the workmen remove to a safe distance, the gang boss turns on the current, a dull, heavy explosion is heard and a mass of loose rock salt awaits the workmen, who load it on the cars.

There are several miles of railroad track in the mine, and the grades are so easy that one mule draws a load of three tons without any great effort. After the car is loaded it is drawn to the shaft, the gong rings, and in about the length of time it takes to tell about it the salt is dumped into the crushers way up in the top of the head house 130 ft. above the surface. The air down in the mine is pure and sweet, although it has a slight chloric smell and saline taste, and the temperature is about 60 degrees. If one had ever had an idea that there was romance about mining, that idea would be exploded after seeing the roughly dressed miners, some with candles and others with kerosene lamps in their hats, work an hour or so at their hard, unpleasant tasks. At present there are 13 mules in the mine and they stay there all the time. When not at work they are kept in a stable with salt roof, walls and floor, and are fed on oats and baled hay. Not far from the stable is a first class blacksmith shop, and as the busy smith hammers away at his anvil, sharpening the drills and other tools, he makes a cheery picture in sharp contrast with the dull surroundings. The salt in the mine is of a dark gray color and looks not unlike common rock; but as it is crushed and pulverized it grows whiter, until the finest salt is as fine and white as any flour, and 99·44/100 pure. Entering the cage again you soon reach the surface and take a renewed delight in the fresh air, green trees, and deep blue of heaven, after your brief experience in the Retsof mine. The daily output runs from 400 to 600 tons, and every 24 hours 40 cars on the average are shipped to the different parts of America. The great bulk of salt is shipped to the West, much of it being used by the Chicago and Kansas City packing houses, and a considerable quantity is sent in the lump to the cattle ranches for stock purposes. That the company could sell all the salt they could get there is no doubt, as they are constantly behind their orders. In order to increase their capacity they are putting down a new shaft, the same size as the first, and 25 rods away from it. Shaft No. 2 is down about 900 ft. and when completed will connect with the main gangway. It will be used for lowering the miners and supplies, and for improving the circulation, so that the main shaft will be devoted solely to raising salt. There are now employed in the mine and around the buildings 500 men, over half of whom are Italians, but as considerable skilled labor is employed, the pay roll is very large.

The Retsof Salt Company has come to stay. The mine is a decidedly paying property, and will grow more valuable year by year, and the concern deserves all the prosperity it will get. 'A New York company has just broken ground at Livonia Station for a shaft of the same size as the Retsof, and a Chicago corpora-

tion is sinking a test well on lands adjoining the Retsof property, with the intention of putting down a shaft in the near future. Who can tell but that 20 years from now all our salt will be mined, instead of evaporated, as now?

THE FOOT BELLOWS AS A MUSICAL INSTRUMENT.

IN Number 764 of the SUPPLEMENT, you give from *La Nature* an ingenious instrument called the musical bellows, of which the writer says: "We have played bellows and flute duos with piano accompaniment, and can assert that the effect was very fine and much appreciated by the auditors." I have found the musical bellows a very handy instrument in the lecture room for producing tones of any desired pitch, great intensity, and fair quality before the manometric flame apparatus, the phonautograph, the phoneidoscope, any other apparatus to render sound visible. The difficulty with the hand bellows is that it requires the active use of both hands and no little exertion on the part of the operator.

The accompanying sketch suggests another form of the musical bellows which I hit upon one day when needing a strong, clear tone and a *free* hand for the manipulation of other apparatus. A brass tube inserted in the end of the hose makes the playing easier. The foot bellows gives a stronger, steadier

current of air, increases the range to near four octaves, and does not tire the player.

It is not necessary to repeat here the excellent suggestions made in the former article as to manipulation.

JOHN B. DE MOTTE, Professor of Physics.

De Pauw University, Greencastle, Ind.
October 20, 1890.

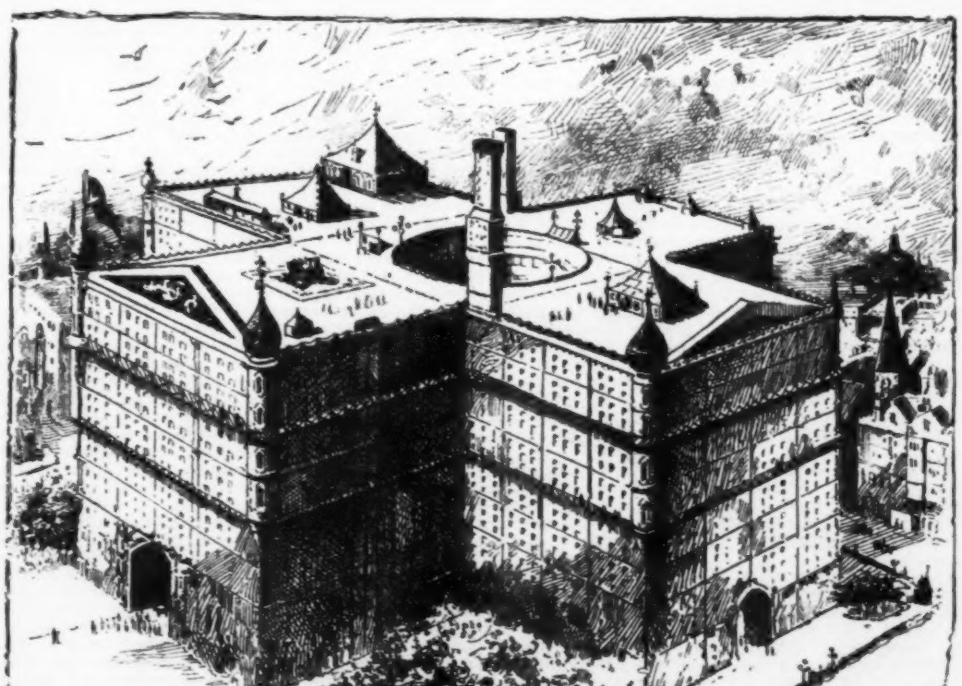
FLATS FOR PROFESSIONAL MEN.

ON a piece of ground 100 yards square it would be possible to construct a building twenty stories high, conforming to the recognized rules of architecture for lofty buildings. This structure might be made to constitute a self-contained town. If it were built on the principle of a cross, with a wide well in the center, it would contain twenty flats on each floor, with an area of 37½ ft. to each flat, and in addition there would be eight inner rooms 37½ ft. each on each floor, with light obtained from the circular well. Outside these rooms would be a wide balcony.

The roof would form one of the principal features. The building being in the form of a cross, nearly 300 ft. by 225 ft., there would be ample room for a promenade, flower garden, concert room, band stand, refreshment kiosks, etc. At various points on the outside balconies would extend around the building, with shelters and seats, affording a splendid promenade, with a bird's-eye view of London. The central or inner rooms on the half-way floor should be formed into a huge general store conducted on co-operative principles for the benefit of the building and its occupants. A club room should be set apart on this floor, with billiards, buffet, dining rooms, and so forth. The attractions of the roof and halfway store and club rooms would lessen the necessity for those in the higher floors to descend to the street.

Presuming the building to be twenty stories high, with twenty flats on each floor, there would be 400 flats at an average rental of £55, the total rental thus producing £22,000 a year. Add to this the profit accruing from the trading and supply of necessaries to the estimated 1,000 to 1,200 inhabitants, £22,000 is 10 per cent. interest on £220,000.

A fireproof building constructed on these lines, fitted throughout with modern requirements and good sanitation, would prove an immense benefit to those who now have to pay 25 and 30 per cent. of their incomes for a few dingy rooms in a back street. Mr. J. Louis Kight, of London, proposes the above in the *Daily Graphic.*



FLATS FOR PROFESSIONAL MEN.

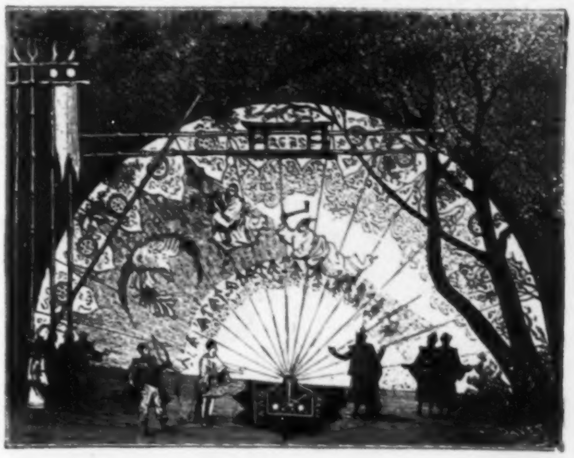


FIG. 1.—VIEW OF THE FAN AT THE PARIS OPERA HOUSE.

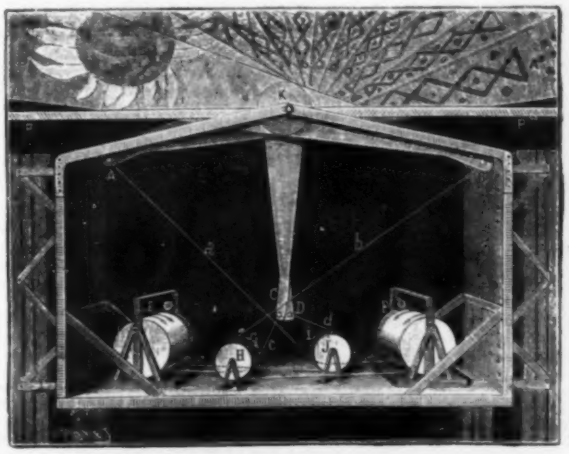


FIG. 2.—APPARATUS FOR MANEUVERING THE FAN.

SCIENCE IN THE THEATER.

THE Paris Opera House last year put upon the boards a new ballet called "The Dream," the scenery of which, as regards the maneuvering of the principal piece, may be summarized as follows: The act is supposed to take place in a Japanese city. A bow and arrow contest is organized upon a public place. From a bower of branches there descends in the center of the stage a long streamer that is to serve as a target. After an arrow has hit the center, the streamer ascends into the foliage, and at the same time an immense fan that conceals the entire back of the stage spreads out.

The heroine of the ballet goes to dream at the base of the fan, the center sticks of which separate slightly in order to permit of the appearance of a fairy who attracts the sleeping danseuse to her.

When the curtain rises in the succeeding tableau, the fan is no longer visible to the spectator. It has separated at the middle and folded back to the right and left upon the stage floor, exposing a superb fairy scene. At the end of this tableau, the fan spreads again and hides the back of the stage just long enough to allow the scene behind it to be changed. When it descends again in separating into two halves, the heroine, whose dream is at an end, is observed in the primitive landscape.

Let us say just here that this role is filled by Miss Mauri, the star danseuse of our Opera House, whose grace and talent would suffice to make any ballet successful.

As for the fan, which plays so important a part in the decoration of the dream, Mr. Gailhard, director of the opera, conceived the first idea of it.* This screen produces a fine effect, and, at the same time, facilitates the changes of the tableau. A fan, moreover, seems very appropriate in a Japanese ballet.

We shall now show how Mr. Vallenot, chief machinist of the Opera House, has skillfully realized the construction and maneuver of it.

It scarcely differs (Fig. 1) as to principle from an ordinary fan; but its sticks are 23 feet in length, that is to say, two stories high. There are in all ten sticks that revolve around the same axis, K (Fig. 2), and slightly overlap. They are connected by strips of canvas of the same width. The use of this canvas has permitted of reducing the thickness of the folded fan to a minimum. The interval disposable between two timbers for the passage of this fan was in all but 10 inches,

* A similar fan has been in use in a New York music hall for several years.

and this necessarily limited the total thickness of the sticks and constituted the principal difficulty in their construction.

The two extreme sticks, A and B, and the two center ones, C and D, are prolonged beneath the axis of rotation, K. It is these four sticks only that are acted upon in order to open and close the fan. The others participate in their motion through arcs of iron which connect one with another. The maneuvering apparatus (Fig. 2) consists of an iron and wooden frame placed under the floor, P P, of the stage. This frame is provided with two windlasses, E and F, and four guide pulleys, G, H, I, and J.

To the stick, A, is fixed a cable, *a*, which passes under the pulley, I, and is hooked to the drum of the windlass, F. So, too, to the stick, B, is fixed a cable, *b*, which passes under the pulley, H, and is hooked to the drum of the same windlass. On another hand, the cables, *c* and *d*, fixed to the center sticks, C and D, pass respectively under the pulleys, G and J, and are hooked to the drum of the windlass, E.

Let us now see how the maneuver of the fan is effected.

The fan is arranged in advance under the stage. In the middle of the first act it is mounted vertically, all closed, upon the stage, behind the streamer, which completely hides this maneuver, thus giving the spectators the surprise of suddenly seeing the great folds of the fan opening in order to hide the back of the stage.

Let us suppose the fan open. In order to close it we act upon the windlass, F. The two sticks, A and B, rise with a uniform motion and carry along the other sticks in succession until the fan is upright, entirely closed.

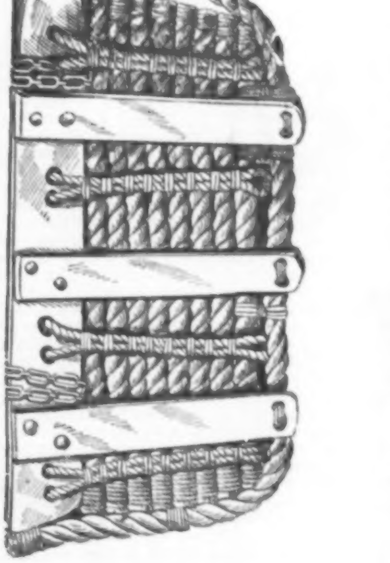
In order to unfold it, it will suffice to effect the opposite maneuver. Let us suppose the fan unfolded. If we revolve the windlass, E, slightly, the two cables, *c* and *d*, will unwind, and the two center sticks, C and D, of the fan will progressively separate from each other until each half rests folded upon the stage floor. In order to afterward unfold it again, it will suffice to raise the sticks, C and D, upright by acting upon the windlass, E.

All these maneuvers are very simple, and are effected without effort by one man only at each windlass. They are, moreover, facilitated by the use of cables provided with counterpoises, which are hooked above to the four principal sticks and pass over guide pulleys placed in the semicircles. These cables are concealed behind a decoration representing foliage which hides the edges of the fan.

Let us add in conclusion that all the scenery of the new ballet was painted by Mr. Lavastre, the eminent artist, whose brush has now for a long time furnished our Opera House with numerous masterpieces.—*La Nature.*

A TEMPORARY RUDDER.

It has been a point long mooted among seafaring men how Capt. Samuels steered the famous clipper ship Dreadnaught into Fayal after he had lost his rudder at sea, over twenty years ago. George H. Lord, living at 1232 Bedford Avenue, Brooklyn, N. Y., tells the story of that remarkable performance, which differs materially from the generally accepted theories. Mr. Lord said he joined the Dreadnaught at Liverpool as third officer, having there left his ship, the Neptune's

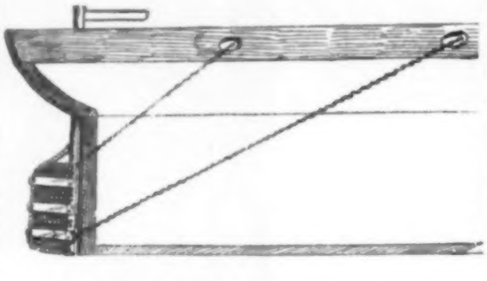


LORD'S JURY RUDDER.

Car, of which he had been chief officer. Capt. Samuels had a crew of negroes and white officers. When midway of the Atlantic, while wearing ship one day, the rudder was carried away, all the gudgeons, pintals, and everything except the rudder head being torn from their fastenings. It was blowing a gale at the time, and Capt. Samuels was in the cabin with a broken leg. Various methods were adopted to build a temporary rudder. A main yard, put one end over the stern and oar-shaped blades attached to the lower part of the yard, was tried. Hawsers were passed out of each after chock and tackles made fast to them, but both these expedients failed to steer the ship. Then Third Officer Lord volunteered to manufacture a temporary rudder, a model of which he has brought to the *American Shipbuilder* office.

The following is Mr. Lord's account of how he rigged and shipped the jury rudder for the Dreadnaught. It will be read with interest, as it is from the man who planned and successfully carried out this novel method of steering vessels whose rudders may have been carried away at sea:

"In making this rudder you can use any spar you may have; I used a topmast. In the first place I measured 10 feet from the head of the mast, then cut the two sides flat that distance. Then a 12 inch hawser was cut into 10 foot lengths and laid alongside one another two deep. I then cut pieces of deal 3 feet long, and nailed them on the flat part of the mast, one on each side, to hold the hawser that formed the blade of the rudder. Then I took the topsail sheet and made a clove hitch one foot from the heel of the rudder post



SHOWING HOW THE RUDDER WAS ATTACHED.

and another one the same way one foot from the head of the rudder blade. Holes were then bored two inches apart along the rudder post. I cut the hawser in 10 feet lengths, whipped them and placed them on the rudder post, two pieces abreast and one on top of the other until it was 3 feet wide; then took 3 inch rope, put it through the holes in the rudder post and made straps of it around the blade; then took rattling stuff and crossed between every layer of the hawser and around the strips and hove all well taut. The two last pieces of hawser were spiked to the head of the rudder post just above the top of the rudder blade. Then the rudder was all ready for shipping with the fid hole for a tiller. I put the rudder on the taffrail with the head forward, put a rope down through the rudder post and up over the stern and fastened it to the head of the rudder post, then passed the upper guy through the quarter chocks and the lower ones through the midship chock, then launched the rudder over the stern, hauled up on the rudder rope that was fast to the head and on the guyer at the same time, and the rudder came up to the stern post without any trouble. I put the tiller in the fid hole and made sail. You can stay or wear ship with it the same as with any other rudder. This is the rudder that took the ship Dreadnaught into Fayal when all other plans had failed."

When all was ready, said Mr. Lord, an attempt was made to launch the contrivance, but through some fault of the sailors it was lost. Not discouraged, he set to work to make another. All night the crew worked, and at 10 o'clock the ship had topgallant sails set and was going along finely with one man at the wheel. The work of getting the new rudder into position, although a difficult job, was successfully accomplished, and by keeping the tackles attached to the preventer chains hauled well taut, the contrivance was kept in its place until the ship reached Fayal.

Mr. Lord says he got his idea of the novel substitute for a regular rudder while serving on board the ship Danube, when a similar disaster occurred. The model as shown is certainly an ingenious contrivance and deserves the merit of novelty and utility, and as the inventor claims, undoubtedly steered the good ship Dreadnaught into port.—*American Shipbuilder.*

A NEW TORPEDO BOAT.

The trial trip of a torpedo boat constructed by Messrs. Yarrow & Co., and possessing certain novel features, was satisfactorily carried out on Nov. 13, and is thus described by the London *Engineer:*

The average speed on a two hours run was 24·436 knots, or 28·1 statute miles per hour, carrying a load corresponding to the equipped condition, a magnificent result for a vessel of these dimensions. The Bathurst is the last of six boats built by Messrs. Yarrow & Co. for the Argentine government. These are all 130 ft. long by 13 ft. 6 in. beam on the water line, and have a displacement of about seventy-six tons, with a load of fourteen tons. There are eleven watertight compartments. The skin plating of the hull is of mild steel galvanized, but of greater thickness than is customary with this class of vessel. The fore part is protected by a turtle back, under which are the quarters for the men. The conning tower contains a steering wheel which is adapted to work either by steam or by hand, the steering engine being fixed under the deck in the after port corner of the engine room.

Aft of this compartment are the galley, drinking water tanks, and sundry stores. Next come the boiler and machinery compartments. Engineer accommodation is aft of the engine room, and the officers' cabin with a pantry are in the after part of the vessel.

The armament consists of one 18 in. bow torpedo tube for direct ahead fire; two 18 in. tubes for side discharge, placed on a turntable aft at an angle of 5 deg. with each other and arranged, if desired, for firing simultaneously, so that the two torpedoes take slightly divergent courses, thereby considerably increasing the probability of hitting the object aimed at, which system was introduced by Messrs. Yarrow & Co. some years ago, and since extensively adopted in the British Admiralty.

There are also two 3 pounder quick firing guns, and one double barreled one inch Nordenfelt, and a powerful search light will be placed on the conning tower.

The maneuvering power of these boats is somewhat remarkable, as they are able, at full speed, to turn within a circle the radius of which is only a trifle in excess of the length of the boat. This result is obtained by means of only one rudder of the simplest construction, which is designed in such a manner that when hard over it counteracts the natural heel of the boat, thus maintaining a steady platform and avoiding at the same time any possible risk of a dangerous angle of heel.

In all these respects the boat very closely resembles others previously built by Messrs. Yarrow & Co. The propelling machinery is, however, of a new type, and the success attained with it goes to prove that it possesses exceptional merits. It has long been known that all vessels will vibrate more or less when their "period" coincides with that of the engines, and curiously enough the engines always have a tendency to run rhythmically with the vibration period of the hull. Now, at the cruising speed usually adopted for torpedo boats, it happens that there is a close approximation to the vibration period, and such vessels may and often do prove excessively uncomfortable to their crews under such conditions, although there is scarcely any vibration when going dead slow or at full speed. In the Bathurst a very successful attempt has been made to get over this trouble. The engines are of the quadruple expansion type, the four cylinders being combined in such a way as to get the most uniform possible turning moment combined with perfect balance. There are four cranks on one shaft, the two aftermost cranks being opposite each other, and at right angles to the two forward cranks, which are also opposite each other.

The four cylinders are arranged in the following order, beginning forward: The figures are the diameters in inches: 14, 27, 20, 36. The exhaust from the 14 in. cylinder passes by the 27 in. cylinder, and goes to that 20 in. in diameter. From this the steam returns to the 27 in. cylinder, and goes to the last—36 in. in diameter. All the distributing valves are pistons. The valve gear is the ordinary shifting Stephenson link, the links being very long. The stroke for all the cylinders is the same—16 in. The exhaust from the last cylinder passes into a horizontal copper cylindrical surface condenser on the port side of the engine room. The cooling water is driven through it by a small centrifugal pump and engine with a vertical cylinder. Fixed on the forward bulkhead dividing the engine room from the stokehold is the fan engine, the fan itself being in the stokehold. In the after starboard corner is a dynamo and its engine for search light work. In the forward corner on the same side is a vertical engine and air compressor for charging the torpedoes. There is also a Kirkaldy distiller for supplying fresh water for the boiler, and a tank is provided for the same purpose which holds about a ton. At the forward end of the engine are situated the air and feed pumps, driven by a short piece of shaft with a slip coupling.

The boiler is of the locomotive type. The fire box is of enormous dimensions, there being 36 square feet of grate surface. There are two fire doors. The ash pan is fitted with a special arrangement, patented by Mr. Yarrow, which prevents the entrance of water should the boat spring a leak. The fire box stands, so to speak, in a species of tank, carried up some feet. Over the edge of this tank the air for combustion has to find its way. Water could not get in, of course, until it had reached the limit of the top of the tank. The furnace doors are fitted with heavy latches, to prevent them from being blown open in the event of a tube bursting, and in that case all the steam would have to find its way up the chimney. It would be kept out of the stokehold by self-acting light hinged valves provided for the purpose, which are placed in such a position that they are quite out of harm's way and cannot be tampered with.

It is a noteworthy fact that Messrs. Yarrow & Co. are in no way troubled by leaks as a result of the use of forced draught. They have worked boilers with as much as 10 in. of air pressure, burning or sending up the chimney as much as 140 lb. of coal per square foot of grate per hour, and the boilers have withstood this extraordinary test. As improvements have been effected, the air pressures have been reduced, and it will be seen that the Bathurst only needs 3½ in. of pressure in her stokehold. The success which Mr. Yarrow has attained with his boilers is the result of numberless experiments carried out over a series of years. In the Argentine boats the fire boxes are wholly of copper, with brass tubes, and care has been taken that there shall be "breathing" room. But although Mr. Yarrow greatly prefers copper, it should be mentioned that he has obtained excellent results with steel fire boxes; but the copper and brass are far more trustworthy than steel. In the use of steel fire boxes and tubes there is always an element of uncertainty which it is desirable to avoid, and this is fully confirmed by locomotive practice both in this country and in the United States.

On Thursday morning, the 13th Nov., the Bathurst started from the Isle of Dogs at 11:10 A.M., in charge of Mr. Crohn, who has had much to do with the development of the quadruple expansion engines of the boat. There were on board, representing the Argentine government, Captain Garcia, Captain Spurr, chief of the Naval Commission, Mr. Hughes, and Mr. Henry, and several other gentlemen. She proceeded at half speed until Gravesend was reached, the engines making about 220 revolutions per minute. Fast running is not permitted higher up the river, because of the swell raised.

Gravesend past, the stokehold hatch, which had been hitherto open, was closed. Then came the subdued roar of the fan, and brown smoke began to roll from the top of the chimney. The fuel adopted was briquettes made from Welsh coal, and may be regarded as about equal to Nixon's navigation. The heavy firing necessary at first to fill the furnace to the proper point always results in the temporary production of smoke, which soon clears away as the fire burns through. As the boiler pressure rose, the throttle valve was opened by degrees, and the speed rapidly augmented. By the time she reached the Lower Hope the Bathurst was racing through the water at twenty-three knots, but the engines were not yet running full speed. She ran down past the measured mile some considerable distance and then turned and proceeded to make six runs. The results are given in the accompanying table. After the runs had been made, she ran down nearly to Southend at full speed, turned, and

Load carried, 12 tons. Displacement, 75·5 tons.

Steam in Boiler.	First Receiver.	Second Receiver.	Third Receiver.	Vacuum.	Air in Stokehold.	Revolutions, On Knot.	Revolutions, Per Minute.	Time on Knot.	Speeds.	Mean Speeds.	Second Means.	True Mean Speed.
				in.	in.			m. s.				
199	74	35	4	23·7	3·3	1080	432	2 30	24·000	24·587		
200	74	35	4	23·5	3·0	1000	432	2 23	25·174	24·851	24·409	
200	75	35	4	23·5	3·2	1100	431·4	2 33	23·529	24·440	24·395	24·453
200	74	35	4	23·2	3·0	1020	431	2 22	25·352	24·364	24·402	
200	74	35	4	23·0	3·4	1120	436·3	2 34	23·376	24·731	24·547	
200	74	35	4	23·2	3·0	1010	439	2 18	26·086			

The total number of revolutions made in two hours at full speed were 51,848. The mean revolutions to make a knot by the formula $\frac{(t \times r_1)+(t_1 \times r)}{t+t_1}$ is 1061·3, and the mean speed by revolutions for the two hours 24·226 knots. The consumption of fuel per hour was 25¼ cwt.

came back at full speed, so running until the two hours trial was ended. During the whole period the engines worked to perfection. They never slowed down. There was no heating or trouble of any kind.

The weather was fine and the water smooth. It was very difficult, however, for those on deck, harried by the wind, to realize the fact that it was a flat calm. The sails of the barges in the river hung straight up and down. The half gale that blew on the deck of the Bathurst blew nowhere else. It was the result of her own rush through the still air. The lines of the boat are very beautiful, and she literally slipped through the water like a fish, the only disturbance being two light frothing waves parted hither and thither by the sweep of her graceful bow and rolling over the still water beneath. Behind her lay a road marked in the waters, little troubled, bubbling and dancing, and on top of it a great arrow head of silver foam, the point ever at her rudder, which indeed called it into being. Vibration there was practically none. The last run on the measured mile was the quickest. Each run was better than its predecessor. She was settling down to her work. She traversed the mile in 2 min. 18 sec., flying as it were on the water rather than driven through it, and the engines the while running at 439 revolutions per minute. It seems no light thing that a piston 3 ft. in diameter should be started and stopped 978 times in a minute, or over sixteen times in each second, attaining a velocity of 1,840 ft. per minute at mid-stroke. Truly a wonderful performance, but well within the powers of the engines, which, for the sake of experiment, were once tried without the propeller at considerably over 500 revolutions per minute.

In the sister Argentine boats the engines are triple expansion, and the pressure 170 lb. Their indicated power was 1,120 horses. There seems to be no doubt that the quadruple engines and 200 lb. steam give a far better result, the indicated power being over 1,230, or a gain of 110 horse power on the same consumption. The whole performance of the boat, the boiler and the engine alike, is extraordinary, and, so far as we know, has never been equaled. As to the boat, the trial proved her to have the highest speed, for her length, of any vessel hitherto built, and for a fighting ship it is clear one of the first things to secure is to reduce the area which it presents to the enemy's fire; thus, for example, a torpedo boat of 130 ft. in length would have a better chance of making a successful torpedo attack in the face of the enemy's machine guns than one of 150 ft. in length of the same speed. Concerning the engines we have already spoken. The consumption of fuel was very small, under 2·5 lb. per horse per hour, and this, be it remembered, under conditions very unfavorable to economy. The heating surface in the boiler is about 1,500 square feet. Thus each square foot developed 0·82 indicated horse power. There are 36 square feet of grate, each foot representing over 34 indicated horse power. The boiler made over eight tons of steam per hour.

It may, we think, be well said that such a boat as the Bathurst represents the last refinement of mechanical engineering. It is, indeed, impossible to see in what direction improvement is possible, so long as steel remains the chief material of construction. Possibly aluminum may permit further developments.

[Continued from SUPPLEMENT, No. 780, page 12464.]

THE ELECTROMAGNET.*

By Professor SILVANUS P. THOMPSON, D.Sc., B.A., M.I.E.E.

II.

HERE let me go to a matter which has been one of the paradoxes of the past. In spite of Joule, and of the laws of traction, showing that the pull is proportional to the area, you have this anomaly—that if you take a bar magnet having flat ended poles, and measure the pull which its pole can exert on a perfectly flat armature, and then deliberately spoil the truth of the contact surface, rounding it off, so making the surface gently convex, the convex pole, which only touches at a portion of its area instead of over the whole, will be found to exert a bigger pull than the perfectly flat one. It has been shown by various experimenters, particularly by Nickles, that if you want to increase the pull of a magnet with armatures, you may reduce the polar surface. Old steel magnets were frequently purposely made with a rounded contact surface.

There are plenty of examples. Suppose you take a straight round core, or one leg of a horseshoe would do equally well, and take a flat ended rod of iron of same diameter as an armature. Stick it on endwise, and measure the pull when a given amount of ampere turns of current is circulating round. Then having measured the pull, remove it and file it a little, so as to reduce it at the edges or actually take a slightly smaller piece of iron, or a narrower piece, so that it will actually be exerting its power over a smaller area, you will get a greater pull. What is the explanation of this extraordinary fact? A fact it is, and I will show it to you. Here, Fig. 24, is a small electromagnet which we can place with its poles upward. This was very carefully made, the iron poles very nicely faced, and on coming to try them it was found they were equal, but one pole, A, was a little stronger than the other. We have, therefore, rounded the other pole, B, a little, and here I will take a piece of iron, C, which has itself been slightly rounded at one end,

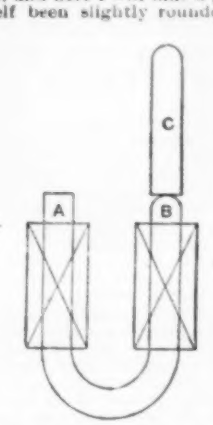


FIG. 24.—EXPERIMENT ON ROUNDING ENDS.

though it is flat at the other. I now turn on the current to the electromagnet, and I take a spring balance so that we can measure the pull at either of the two poles.

When I put the flat end of C to the flat pole A, so that there is an excellent contact, I find the pull about 2½ lb. Now try the round end of C on the flat pole, A. The pull is about 3 lb. The flat end of C on the round pole B is also about 3 lb. But if now I put together two surfaces that are both rounded, I get almost exactly the same pull as at first with the two flat surfaces. I have made many experiments on this, and so have others.

Take the following case:

There is hung up a horseshoe magnet, one pole being slightly convex and the other absolutely flattened, and there is put at the bottom, on a square bar armature, over which is slipped a hook to which weights can be hung. Which end of the armature do you think will be detached first?

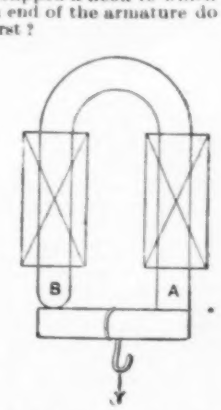


FIG. 25.—EXPERIMENT OF DETACHING ARMATURE.

If you were going simply by the square inches, you would say this square end will stick on tighter, it has more gripping surface. But, as a matter of fact, the other sticks tighter. Why? We are dealing here with a magnetic circuit. There is a certain total magnetic reluctance all round it, and the whole number of magnetic lines generated in the circuit depends on two things—on the magnetizing force and on the reluctance all round, and, saving a little leakage, it is the same number of magnetic lines which come through at B as go through at A. But here, owing to the fact that there is at B a better contact at the middle than at the edges of the pole, the lines are crowded into a smaller space, and therefore at that particular place $\mathbf{B}_1$, the number of lines per square inch runs up higher, and when you square the larger number, its square becomes still larger in proportion. In comparing the square of smaller $\mathbf{B}$, with the square of greater $\mathbf{B}_1$, the square of the smaller $\mathbf{B}$, over the larger area turns out to be less than the square of the larger $\mathbf{B}$, integrated over the smaller area. It is the law of the square coming in.

As an example take the case of a magnet pole formed on the end of a piece of round iron 1·15 inch in diameter. The flat pole will have 1·05 inches area. Suppose the magnetizing forces are such as to make $\mathbf{B}_1$ = 903,000, then, by Table VI., the whole pull will be 118·75 lb., and the actual number of lines through the contact surface will be $\mathbf{N}$ = 94,815. Now suppose the pole be reduced by rounding off the edge till the effective contact area is reduced to 0·9 sq. inch. If all these lines were crowded through that area, that would give a rate of 105,630 per square inch. Suppose, however, that the additional reluctance and the leakage reduced the number by two per cent., there would still be 103,500 per square inch. Reference to Table VI. shows that this gives a pull of 147·7 lb. per sq. inch, which multiplied by the reduced area 0·9 gives a total pull of 132·9 lb., which is larger than the original pull.

Let me show you yet another experiment. This is the same electromagnet (Fig. 24), which has one flat pole and one rounded pole. Here is an armature, also bent, having one flat and one rounded pole. If I put flat to flat, and round to round, and pull at the middle, the flat to flat detaches first. But if we take round to flat, and flat to round, we shall probably find they are about equally good—it is hard to say which holds the stronger.

The law of retraction can again be applied to test the so-called distribution of free magnetism on the surface.

This is a subject on which I shall have to say a good deal. We must, therefore, carefully consider what is meant by the phrase. Let Fig. 26 be a rough drawing

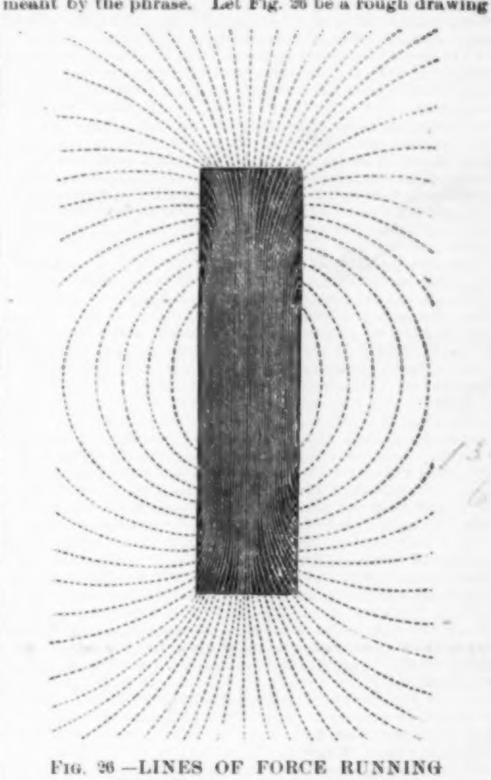


FIG. 26.—LINES OF FORCE RUNNING THROUGH BAR MAGNET.

of an ordinary bar magnet. Every one knows that if we dip such a magnet into iron filings the small bits of iron stick on more especially at the ends, but not exclusively, and if you hold it under a piece of paper or card board, and sprinkle iron filings on the paper, you obtain curves like those shown on the diagram. They attest the distribution of the magnetic forces in the external space. The magnetism running internally through the body of the iron begins to leak out sideways, and finally all the rest leaks out in a great tuft at the end.

These magnetic lines pass round to the other end, and there go in again, and the place where the steel is internally most highly magnetized is this place across the middle, where externally no iron filings at all stick to it. Now we have to think of magnetism from the inside and not the outside. This magnetism extends in lines, coming up to the surface somewhere near the ends of the bar, and the filings stick on wherever the magnetism comes up to the surface. They do not stick on at the middle part of the bar, where the metal is really most completely permeated through and through by the magnetism. There are a larger number of lines per square centimeter of cross section in the middle region where none come up to the surface, and no filings stick on. Now, we may explore the leakage of magnetic lines at various points of the surface of the magnet by the method of traction. We can thereby arrive at a kind of measure of the amount of magnetism that is leaking, or, if you like to call it so, of the intensity of the "free magnetism" at the surface. I do not like to have to use these ancient terms, because they suggest the ancient notion that magnetism was a fluid, or, rather, two fluids, one of which was plastered on at one end of the magnet, and the other at the other, just as you might put red paint or blue paint over the ends. I only use that term because it is already more or less familiar. Here is one of the ways of experimentally exploring the so-called distribution of free magnetism. The method was, I believe, originally due to Plucker, at any rate, it was much used by him. This little piece of apparatus was arranged by my friend and predecessor, Professor Ayrton, for the purpose of teaching his students at the Finsbury College. Here is a bar magnet of steel marked in centimeters from end to end. Over the top of it there is a little steelyard, consisting of a weight sliding along an arm. At the end of that steelyard there is suspended a small bullet of iron. If we bring that bullet into contact with the bar magnet anywhere near the end, and equilibrate the pull by sliding the counterpoise along the steelyard arm, we shall obtain the definite pull required to detach that piece of iron. The pull will be proportional, by Maxwell's rule, to the square of the number of magnetic

* Lectures delivered before the Society of Arts, London, 1890. From the Journal of the Society.

lines coming up from the bar into it. Shift the magnet on a whole centimeter, and attach the bullet a little further on. Now equilibrate it, and we shall find it will require a rather smaller force to detach it. Try it again, at points along from the end to the middle. The greatest force required to detach it will be found at the extreme corner, and a little less a little way on, and so on, until we find at the middle the bullet does not stick on at all, simply because there are here no magnetic lines leaking. The method is not perfect, because it obviously depends on the magnetic properties of the little bullet, and whether much or little saturated with magnetism. Moreover, the presence of the bullet perturbs the very thing that is to be measured. Leakage into air is one thing, leakage into air perturbed by the presence of the little bullet of iron, which invites leakage into itself, is another thing. It is an imperfect experiment at the best, but a very instructive one. This method has been used again and again in various cases for exploring the apparent magnetism on the surface. I shall use it hereafter, reserving the right to interpret the result by the light of the law of traction. I now pass to the consideration of the attraction of a magnet on a piece of iron at a distance. And here I come to a very delicate and complicated question. What is the law of force of a magnet—or electromagnet—acting at a point some distance away from it? I have a very great controversy to wage against the common way of regarding this. The usual thing that is proper to say is that it all depends on the law of inverse squares. Now, the law of inverse squares is one of those detestable things needing to be abolished, which, although it may be true in abstract mathematics, is absolutely inapplicable with respect to electromagnets. The only use, in fact, of the law of inverse squares, with respect to electromagnetism, is to enable you to write an answer when you want to pass an academical examination, set by some fossil examiner, who learned it years ago at the university, and never tried an experiment in his life to see if it was applicable to an electromagnet. In academical examinations they always expect you to give the law of inverse squares. What is the law of inverse squares? We had better understand what it is before we condemn it. It is a statement to the following effect—that the action of the magnet (or of the pole some people say), at a point at a distance away from it, varies inversely as the square of the distance from the pole. There is a certain action at one inch away. Double the distance. The square of that will be four, and, inversely, the action will be ¼. At double the distance the action is ¼. At three times the distance the action is 1/9, and so on. You just try it with any electromagnet. Nay, take any magnet you like, and unless you hit upon the particular case, I believe you will find it to be universally untrue. Experiment does not prove it. Coulomb, who was supposed to establish the law of inverse squares by means of the torsion balance, was working with long thin needles of specially hard steel, carefully magnetized, so that the only leakage of magnetism from the magnet might be as nearly as possible leakage in radiating tufts at the very ends. He practically had point poles. When the only surface magnetism is at the end faces, the magnetic lines leak out like rays from a center, in radial lines. Now the law of inverse squares is never true except for the action of points. It is a "point" law. If you could get an electromagnet or a magnet with poles so small in proportion to its length that you can consider the end face of it as the only place through which magnetic lines leak up into the air, and the ends themselves so small as to be relatively mere points; if, also, you can regard those end faces as something so far away from whatever they are going to act upon that the distance between them shall be large compared with their size, and the end itself so small as to be a point, then, and then only, is the law of inverse squares true. It is a law of the action of points. What do we find with electromagnets? We are dealing with pieces of iron which are not infinitely long with respect to their cross section, and generally possessing round or square end faces of definite magnitude, which are quite close to the armature, and which are not so infinitely far away that you can consider the polar face a point as compared with its distance away from the object upon which it is to act. Moreover, with real electromagnets there is always lateral leakage. The magnetic lines do not all emerge from the iron through the end face. Therefore, the law of inverse squares is not applicable to that case. What do we mean by a pole, in the first place? We must settle that before we can even begin to apply any law of inverse squares. When leakage occurs all over a great region, as shown in this diagram, every portion of the region is polar. The word polar simply means that you have a place somewhere on the surface of the magnet where filings will stick on; and if filings will stick on to a considerable way down toward the middle, all that region must be considered polar, though more strongly at some parts than at others. There are some cases where you can say that the polar distribution is such that the magnetism leaking through the surface acts as if there were a magnetic center of gravity a little way down, not actually at the end. But cases where you can say there is such a distribution as to have a magnetic center of gravity are strictly few. When Gauss had to make up his magnetic measurements of the earth, to describe the earth's magnetism, he found it absolutely impossible to assign any definite center of gravity to the observed distribution of magnetism over the northern regions of the earth, that, indeed, there was not in this sense any definite magnetic pole to the earth at all. Nor is there to our magnets. There is a polar region, but not a pole. And if there is no center of gravity of the surface magnetism that you can call a pole from which to measure distance, how about the law of inverse squares? Allow me to show you an apparatus (Fig. 27), the only one I ever heard of in which the law of inverse squares is true. Here is a very long thin magnet of steel, about 3 ft. long, very carefully magnetized so as to have no leakage until quite close up to the end. The consequence is that for practical purposes you may treat this as a magnet having point poles, about an inch away from the ends. The south pole is upward, and the north pole is below, resting in a groove in a base-board which is graduated with a scale, and is set in a direction east and west. I use a long magnet, and keep the south pole well away, so that it shall not perturb the action of the north pole, which, being small, I ask to be allowed to consider as a point. I am going to consider this point as acting on a small compass needle suspended over a card under this glass case constituting a little magnetometer. If this were properly arranged in a room free from all other magnets, and set so that that needle shall point north, what will be the effect of having the north pole of the long magnet at some distance eastward? It will repel the north end and attract the south, producing a certain deflection which we can read off; reckoning the force which causes it by calculating the tangent of the angle of the deflection. Now, let us move the north pole (regarded

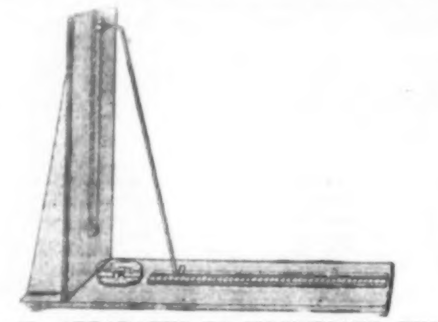


FIG. 27.—APPARATUS TO ILLUSTRATE THE LAW OF INVERSE SQUARES

as a point) nearer or farther, and study the effect. Suppose we halve the distance from the pole to the indicating needle, the deflecting force at half the distance is four times as great; the force at double the distance is one-quarter as great. Wherefore? Because, first, we have taken a case where the distance apart is very great, compared with the size of the pole; secondly, the pole is practically concentrated at a point; thirdly, there is only one pole acting; and, fourthly, this magnet is of hard steel, and its magnetism in no way depends on the thing it is acting on, but is constant. I have carefully made such arrangements that the other pole shall be in the axis of rotation, so that its action on the needle shall have no horizontal component. The apparatus is so arranged that whatever the position of that north pole, the south pole, which merely slides perpendicularly up and down on a guide, is vertically over the needle, and therefore does not tend to turn it round in any direction whatever. With this apparatus one can approximately verify the law of inverse squares. But this is not like any electromagnet ever used for any useful purpose. You do not make electromagnets long and thin, with point poles a very large distance away from the place where they are to act. No; you use them with large surfaces close up to their armature.

There is yet another case which follows a law that is not a law of inverse squares. Suppose you take a bar magnet, not too long, and approach it broadside on toward a small compass needle, Fig. 28. Of course, you

FIG. 28.—DEFLECTION OF NEEDLE CAUSED BY BAR MAGNET BROADSIDE ON.

know as soon as you get near the compass needle it turns round. Did you ever try whether the effect is inversely proportional to the square of the distance reckoned from the middle of the compass needle to the middle of the magnet? Do you think that the deflections will vary inversely with the squares of the distances? You will find they do not. When you place the bar magnet like that, broadside on to the needle, the deflections vary as the cube of the distance, not the square.

Now, in the case of an electromagnet pulling at its armature at a distance, it is utterly impossible to state the law in that misleading way. The pull of the electromagnet on its armature is not proportional to the distance, nor to the square of the distance, nor to the cube, nor to the fourth power, nor to the square root, nor to the three-halfth root, nor to any other power of the distance whatever, direct or inverse, because you find, as a matter of fact, that as the distance alters, something else alters too. If your poles were always of the same strength, if they did not act on one another, if they were not affected by the distance in between, then some such law might be stated. If we could always say, as we used to say in the old language, "at that pole," or "at that point" there are to be considered so many "units of magnetism," and at that other place so many units, and those are going to act on one another; then you could, if you wished, calculate the force by the law of inverse squares. But that does not correspond to anything, in fact, because the poles are not points, and further, the quantity of magnetism on them is not a fixed quantity. As soon as the iron armature is brought near the pole of the electromagnet there is a mutual interaction; more magnetic lines flow out from the pole than before, because it is easier for magnetic lines to flow through iron than through air. Let us consider a little more narrowly that which happens when a layer of air is introduced into the magnetic circuit of an electromagnet. Here we have (Fig. 29) a closed magnetic circuit, a ring of iron, uncut, such as that on which we experimented last week. The only reluctance in the path of the magnetic lines is that of the iron, and this reluctance we know to be small. Compare Fig. 29 with Fig. 30, which represents a divided ring with air gaps in between the severed ends. Now air is a less permeable medium for magnetic lines than iron is, or, in other words, it offers a greater magnetic reluctance. The magnetic permeability of iron varies, as we know, both with its quality and with the degree of magnetic saturation. Reference to Table III. shows that if the iron has been magnetized up so as to

FIG. 29.—CLOSED MAGNETIC CIRCUIT.

carry 16,000 magnetic lines per square centimeter, the permeability at that stage is about 320. Iron at that stage conducts magnetic lines 320 times better than air does; or air offers 320 times as much reluctance to magnetic lines as iron (at that stage) does. So then the reluctance in the gaps to magnetization is 320 times as great as it would have been if the gaps had been filled up with iron. Therefore, if you have the same magnetizing coil with the same battery at work, the introduction of air gaps into the magnetic circuit will, as a first effect, have the result of decreasing the number of magnetic lines that flow round the circuit. But this first effect itself produces a second effect. There are

FIG. 30.—DIVIDED MAGNETIC CIRCUIT.

fewer magnetic lines going through the iron. Consequently if there were 16,000 lines per square centimeter before, there will now be fewer—say only 12,000 or so. Now refer back to Table III., and you will find that when $\mathfrak{B}$ is 12,000 the permeability of the iron is not 320, but 1,400 or so. That is to say, at this stage, when the magnetization of the iron has been pushed only so far, the magnetic reluctance of air is 1,400 times greater than that of iron, so that there is a still further throttling of the magnetic circuit by the reluctance so offered by the air gaps.

Apply that to the case of an actual electromagnet. Here is a diagram, Fig. 31, representing a horseshoe

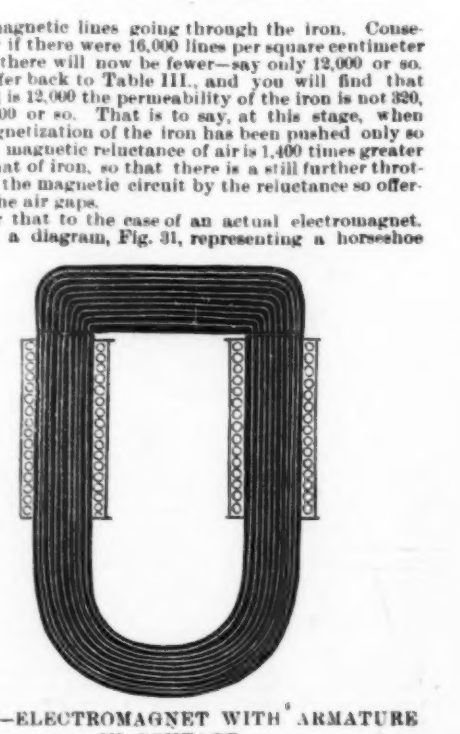


FIG. 31.—ELECTROMAGNET WITH ARMATURE IN CONTACT.

electromagnet with an armature of equal section in contact with it. The actual electromagnet for the experiment is here on the table. You can calculate out from the section, the length of iron, and the table of permeability, how many ampere turns of excitation will produce any required pull. But now consider that same electromagnet, as in Fig. 32, with a small air gap between the armature and the polar faces. The same circulation of current will not now give you as much magnetism as before, because you have interposed air gaps; and by the very fact of putting in reluctance there, the number of magnetic lines is reduced.

Try, if you like, to interpret this in the old way by

the old notion of poles. The electromagnet has two poles, and these excite induced poles in the opposite surface of the armature, resulting in attraction. If you double the distance from the pole to the iron, the magnetic force (always supposing the poles are mere points) will be one-quarter, hence the induced pole on the armature will only be one-quarter as strong. But the pole of the electromagnet is itself weaker. How much weaker? The law of inverse squares does not give you the slightest clew to this all-important fact. If you cannot say how much weaker the primary pole is, neither can you say how much weaker the induced pole will be, for the latter depends upon the former. The law of inverse squares in a case like this is absolutely misleading.

FIG. 32.—ELECTROMAGNET WITH AIR GAPS ONE MILLIMETER WIDE.

Moreover, a third effect comes in. Not only do you cut down the magnetism by making an air gap, but you have a new consideration to take into account. Because the magnetic lines, as they pass up through one of the air gaps along the armature, down the air gap, at the other end, encounter a considerable reluctance, the whole of the magnetic lines will not go that way; a lot of them will take some shorter cut, although it may be all through air, and you will have some leakage across from limb to limb. I do not say you never have leakage under other circumstances; even with an armature in apparent contact there is always a certain amount of sideway leakage. It depends on the goodness of the contact. And if you widen the air gaps still further, you will have still more reluctance in the path, and still less magnetism, and still more leakage. Fig. 33 roughly indicates this further stage. The armature will be far less strongly pulled, because, in the first place, the increased reluctance strangles the flow of magnetic lines, so that there are fewer of them in the magnetic circuit; and, in the second place, of this lesser number only a fraction reach the armature because of the increased leakage. When you take the armature entirely away, the only magnetic lines that go through the iron are those that flow by leakage across the air from one limb to the other. This is roughly illustrated by Fig. 34, the last of this set.

FIG. 33.

Leakage across from limb to limb is always a waste of the magnetic lines, so far as useful purposes are concerned. Therefore it is clear that, in order to study the effect of introducing the distance between the armature and the magnet, we have to take into account the leakage; and to calculate the leakage is no easy matter. There are so many considerations that occur as to that which one has to take into account, that it is not easy to choose the right ones and leave the wrong ones. Calculations we must make by and by—they will be added as an appendix to this lecture—but for the moment experiment seems to be the best guide.

I will therefore refer, by way of illustrating this question of leakage, to some experiments made by Sturgeon. Sturgeon had a long tubular electromagnet made of a piece of old musket barrel of iron wound with a coil; he put a compass needle about a foot away, and observed the effect. He found the compass needle deflected about 23°; then he got a rod of iron of equal length and put it in at the end, and found that putting it in so that only the end was introduced—in the manner I am now illustrating to you on the table—the deflection increased from 23° to 37°; but when he pushed the iron right home into the gun barrel, it went back to nearly 23°. How do you account for that? He had unconsciously increased its facility for leakage when he lengthened out the iron core. And when he pushed the rod right home into the barrel, the extra leakage which was due to the added surface could not and did not occur. There was additional cross section, but what of that? The additional cross section is practically of no account. You want to force the magnetism across some 20 inches of air which resists from 300 to 1,000 times as much as iron. What is the use of doubling the section of the iron? You want to reduce the air reluctance, and you have not reduced the air by putting a core into the tube.

FIG. 34.

There is a paradoxical experiment which we will try next week, that illustrates an important principle. If you take a tubular electromagnet and put little pieces of iron into the ends of the iron tube that serves as core, and then magnetize it, the little pieces of iron will try to push themselves out. There is always a tendency to try and increase the completeness of the magnetic circuit; the circuit tends to rearrange itself, so as to make it easier for the magnetic lines to go round.

Here is another paradoxical experiment. I have here a bar electromagnet, which we will connect to the wires that bring the exciting current. In front of it, and at a distance from one end of the iron core, is a small compass needle with a feather attached to it as a visible indicator, so that when we turn on the current the electromagnet will act on the needle, and you will see the feather turn round. It is acting there at a certain distance. The magnetizing force is mainly spent, not to drive magnetism round a circuit of iron, but to force it through the air, flowing from one end of the iron core out into the air, passing by the compass needle, and streaming round again, invisible, into the other end of the iron core. It ought to increase the flow if we can in any way aid the magnetic lines to flow through the air. How can I aid this flow? By putting on something at the other end to help the magnetic lines to get back home. Here is a flat piece of iron. Putting it on here at the hinder end of the core ought to help the flow of magnetic lines. You see that the feather makes a rather larger excursion. Taking away the piece of iron diminishes the effect. So also in experiments on tractive power, it can be proved that the adding of a mass of iron at the far end of a straight electromagnet greatly increases the pulling power at the end that you are working with; while, on the other hand, putting the same piece of iron on the front end as a pole piece greatly diminishes the pull. Here, clamped to the table, is a bar electromagnet excited by the current; and here is a small piece of iron attached to a spring balance, by means of which I can measure the pull required to detach it. With the current I am employing, the pull is about 2½ lb. I now place upon the front end of the core this block of wrought iron; it is itself strongly held on; but the pull which it itself exerts on the small piece of iron is small. Less than half a pound suffices to detach it. I now remove the iron block from the front end of the core, and place it upon the hinder end. And now I find that force required to detach the small piece of iron from the front end is about 3½ lb., instead of 2½ lb. The front end exerts a bigger pull when there is a mass of iron attached to the hinder end. Why? The whole iron core, including its front end, becomes more highly magnetized, because there is now a better way for the magnetic lines to emerge at the other end and come round to this. In short, we have diminished the magnetic reluctance of the air part of the magnetic circuit, and the flow of magnetic lines in the whole magnetic circuit is thereby improved. So it was also when the mass of iron was placed across the front end of the core; but the magnetic lines streamed away backward from its edges; and few were left in front to act upon the small bit of iron. So the law of magnetic circuit action explains this anomalous behavior. Facts like these have been well known for a long time to those who have studied electromagnets. In Sturgeon's book there is a remark that bar magnets pull better if they are armed with a mass of iron at the distant end, though Sturgeon did not see what we now know to be the explanation of it. The device of fastening a mass of iron to one end of an electromagnet in order to increase the magnetic power of the other end was patented by Siemens in 1862.

(*To be continued.*)

THE PRIMULINE PROCESS.

A NEW PHOTOGRAPHIC PRINTING PROCESS—DIRECTIONS FOR WORKING.

PRIMULINE is the sodium salt of the sulphonic acid derived from a base which appears to be dehydrothiotoluidine, or a condensation derivative of this amine. This new color of the coal tar series is now used as a starting point in producing several tints on calico, and although it is not necessary for us to enter into any elaborate discussion as to the chemical constitution of the benzene derivatives, we may point out that the new body can be regarded as a derivative of cresol, C_7H_7HO, the next homologue above phenol or carbolic acid; or one may regard it as a substitution and condensation product of toluidine, $C_7H_7H_2N$, the base standing next above aniline in the homologous series—methyl-aniline, in fact, $C_6H_4CH_3H_2N$. Just in the same way cresol may be regarded as methyl-phenol, $C_6H_4CH_3HO$. A sulphonic acid may be looked upon as sulphuric acid, SO_2HOHO, in which one of the hydroxyl groups, HO, is replaced by a monovalent radical. Thus, phenyl sulphonic acid would be $SO_2C_6H_5HO$; but in the case of a divalent radical like ethylene, C_2H_4, two of hydroxyl in two of sulphuric acid are replaced, and we obtain ethylene di-sulphonic acid $(SO_2HO)_2C_2H_4$. Sulphonic acids can be obtained by several generic reactions, the most common of which is heating the hydride of the radical with ordinary or fuming sulphuric acid. As an example, we may refer to the production of phenyl-sulphonic acid by the reaction of benzene and sulphuric acid—thus, $C_6H_5H+H_2SO_4=SO_2C_6H_5HO+H_2O$.

We propose now to give working details of the primuline process as applied to the production of prints on calico, but the same details will serve for working on paper if the difference in texture be taken into account, and the manipulation be modified accordingly. At the same time, we may remark that there appears but little inducement to use primuline for paper prints.

One hundred and fifty grains of commercial primuline are heated to the boiling temperature with ten ounces of water, a glass flask or beaker heated on a sand bath being used. The liquor is now poured off from any undissolved matter, on sheets of calico laid in a porcelain dish, the above quantity of dye being sufficient for sixteen pieces of rather thin calico, whole plate size. When in the dye, the sheets should be constantly turned over, one by one, as in toning prints, and if kept moving in the warm dye for ten minutes they will be sufficiently stained. The dish should be kept warm during the operation of dyeing.

When ordinary calico from a draper's shop is used, it is necessary to boil it in water and thoroughly knead or "dolly" it to remove the dressing, a troublesome operation, which is avoided when one can obtain clean calico from a print works.

The dyed calico is now rinsed in water, wrung out, and the pieces are immersed singly in the following solution, the quantities being reckoned for the sixteen pieces, whole plate size:

Commercial nitrite sodium........	100	gr.
Commercial hydrochloric acid.....	½	fl. oz.
Water............................	36	oz.

The nitrite of sodium can be obtained from an operative chemist, or it may be readily prepared in a sufficient state of purity by heating nitrate of sodium to low redness in a silver or porcelain capsule till the loss in weight is a little more than corresponds to the reaction:

$$\underset{(85)}{NaNO_3}=\underset{(16)}{O}+\underset{(69)}{NaNO_2}$$

Care must be taken that the nitrate is quite dry when the first weighing is made.

Under these circumstances the primuline in the cloth will rapidly change into a corresponding diazo derivative, the fabric taking at the same time a reddish brown tint. It is now sensitive to light, exposure serving to destroy the azo derivative, and so prevent its reaction with certain "developers," and it will thus be seen that the process is one giving a positive from a positive.

The pieces of cloth should be turned over a few times in the nitrite bath, and they are then rinsed several times in water to remove the free hydrochloric acid; after which they are laid in a blotting folio to dry. Overdrying with heat is undesirable, as tending to lower the sensitiveness, and, moreover, it would cause any trace of hydrochloric acid to react on the fiber.

The exposure is, perhaps, rather less than for ordinary albumenized paper, and its progress is indicated by the bleaching of the reddish brown azo body to a dingy yellow; and to get the full vigor which the method is yielding, it is necessary to have originals which are somewhat denser than are required for most other analogous copying methods. Indeed, we may at once say that the method appears to us to be more suitable for copying from very dense tracings, or such opaque objects as leaves and twigs of plants, than from ordinary half tone positive transparencies, or the comparatively light tracings which are often employed in making reproductions by the Pellet process (cyanofer). When the sensitive material permeates the whole substance of the support, as in the case of cloth sensitized as now directed, it is extremely necessary that the original should be dense and opaque in order that the light may decompose the sensitive azo body all through the substance of the fabric; should, however, the original not be so completely opaque as to allow of this, it is an advantage to give the back of the cloth a short exposure to light—say, equal to one-fifth or one-sixth of the total exposure. This clears the ground at the back, and does not sensibly affect the vigor of the image. Before development, it is well to thoroughly wet the cloth and wring out the excess of water, otherwise, in order to secure equal action all over, it may become necessary to wring it out while saturated with the developer—a course not always agreeable, especially when the naphthylamine developer is used; this base having a very persistent and characteristic odor, which Dr. A. W. Hofmann used to describe in his lectures as "agreeable and resembling narcissus," although one of the newspaper reporters of the recent British Association meeting characterizes the odor simply as "evil."

The following developers have, among others, been indicated by Messrs. Green, Cross & Bevan, although

as far as we know they have given no definite instructions for compounding developers, an omission which we now supply.

Developer for Red.

Beta-naphthol	40 gr.
Caustic soda or potash	60 gr.
Water	10 oz.

The alkali is dissolved in a small quantity of the water, rubbed up in a mortar with the naphthol, and the rest of the water is now added.

Developer for Orange.

Resorcin	30 gr.
Water	10 oz.

Dissolve and add

Caustic potash or soda	50 gr.

Developer for Purple.

Alpha-naphthyiamine (ordinary naphthylamine)	60 gr.
Commercial hydrochloric acid	1 fl. dr.

Mix the naphthylamine and the acid in a mortar and add

Water	10 oz.

Other developers containing phenols, amido-phenols, and alkaline salts of sulphonic acids of phenols have been indicated by Messrs. Green, Cross & Bevan, but it is sufficient to give the above selection of developers compounded from ingredients to which they refer. The strangest thing, however, is that we cannot find any mention of the use of such benzene derivatives as are strictly in range with the chemicals they indicate, and are now in every day use by photographers for developing purposes. We allude more especially to the sodium salt of amido-betanaphthol-beta-monosulphonic acid which is sold under the name eikonogen, pyrogallic acid or pyrogallol, and hydroquinone, two of which, at any rate, we find not only to have a powerful developing action on the azotized primuline image, but to possess very evident advantages over the developers made with the ingredients indicated by Messrs. Green, Cross & Bevan, advantages so notable that for much of such commercial work as the method is capable of, they will probably be employed to the exclusion of others.

The following are the developers made up with "eikonogen" and "pyro" respectively:

Developer for Ink Black Tones.

"Eikonogen"	60 gr.
Water	10 oz.

Grind the eikonogen in a mortar, add the water, put in the exposed cloth, and keep all in motion till the development is complete. In this case the dissolving of the "eikonogen" and the development of the image proceed simultaneously. The white, crystallized "eikonogen" should be used.

Developer for Brown Tones.

"Pyro"	30 gr.
Water	10 oz.

In every case the full density is completely brought out by the developing solution in few minutes, and the development being finished no fixing is necessary, mere washing being required to remove such soluble chemicals as remain; but after rinsing, it is desirable to wash in soap and water, as this serves to clear the ground somewhat and brighten the image. Ironing between sheets of paper, best done before the prints are absolutely dry, is desirable.

We experience especial satisfaction in having given particulars of a developer capable of producing the ink black tones which were referred to as so desirable when the primuline process was brought before the Photographic Society, and we would point out that whatever patent claims Messrs. Green, Cross & Bevan may have on the process generally, it is quite difficult to suppose that such claims can cover the use of the "eikonogen" developer, unless indeed this agent is distinctly specified in some claim not yet published. It may be pointed out that no general claim, such as "phenol derivatives," or "aromatic sulphonic acids," can be valid unless everything included under such heading will serve the purpose. We may incidentally mention that we have experimented with other developing agents than "eikonogen" and "pyro," among which we may mention orcin (a substance homologous with the resorcin used by Messrs. Green, Cross & Bevan) and catechu; but we do not consider these to have such definite advantage over the developers indicated by Messrs. Green, Cross & Bevan as to justify our giving them that prominence we have given to "eikonogen" and "pyro."

There is much yet to be said about the various applications and modifications of the primuline process, especially as regards the fastness to light of the various tints. We are now making experiments which seem calculated to cast a completely new light on the method.—*Br. Jour. of Photo.*

NOTE.—The process is patented in England by Messrs. Green, Cross & Bevan.—ED. SCIENTIFIC AMERICAN SUPPLEMENT.

MILITARY SIGNALING.

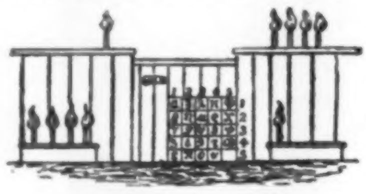
THE practical field work of the First and Second Brigade Signal Corps, as displayed this year at the State camp at Peekskill, has aroused among National Guardsmen a fresh interest in military signaling. From points miles apart the signalmen readily communicated with one another day or night by the aid of flags, heliographs, and torches.

Signaling in some simple forms of very limited application was practiced in remote ancient times. Fire by night and smoke by day were the most common means of transmitting intelligence, and long distances were covered by relays or repetitions from tower to tower or mountain top to mountain top. Night signals were more generally used because fire was more readily and certainly distinguishable at a given distance than smoke. In this way news of victory or of defeat, or of the approach of friends or enemies, was signaled in a manner previously agreed upon.

The first alphabetical plan of signaling of which there is record is known as the system of Polybius, after the Greek general and historian of that name, in whose writings a description of it is found. This system was used as early as the third century B. C. It was very simple and ingenious, and for one purpose and another it has continued in use to the present day. The letters of the alphabet, English letters being here substituted for Greek, were arranged in columns as follows:

	1	2	3	4	5
1	a	f	k	p	u v
2	b	g	l	q	w
3	c	h	m	r	x
4	d	i	n	s	y
5	e	j	o	t	z

The letters signaled to the distant observer were indicated by lights shown at the signaling station. The signaling apparatus was something like this:



SEMAPHORE OF POLYBIUS.

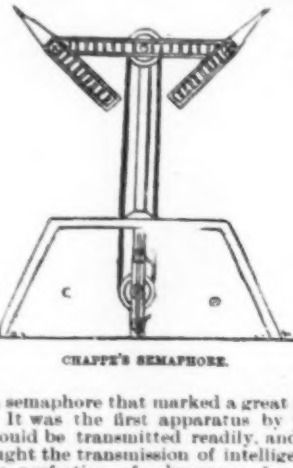
At each signaling station two close fences or screens, each about ten feet in length and about six feet in height, were built. The torches were hidden behind these screens, and, when used as signals, they were shown above them. The letters were marked on five posts or tablets, which were set together in their proper order between the fences. At each station, also, was an optical instrument of two tubes set close together, and so arranged that looking through both tubes at once both fences at the communicating station could be seen, while through one tube only the right hand fence, and through the other only the left hand fence at that station was visible. The use of this appliance was necessary to determine on which side the distant lights were shown, for at night the fences were invisible. In signaling two torches were first held up to attract the attention of the station with which it was desired to communicate, and that station answered with a like signal. When communication had thus been established, the sending of the message was begun.

Lights displayed above the left hand fence at the sending station indicated the number of the letter post or column; lights shown above the right hand fence designated the letter. Thus the showing first of one light on the left of the sending station indicated the first column, and then the showing of one light on the right of the sending station indicated the first letter in that column, the letter *a*. Four lights shown at the left indicated the fourth column, and then five lights on the right indicated the fifth letter of that column, the letter *t*. In this way the words were spelled out.

With a sufficient number of skilled signalmen, a considerable degree of rapidity was attained, and by means of relay stations messages were sent to comparative distant points. This system, with some variations in the detail of application, appears to have come into general use among the armies of the East. There was an elaboration of the system in the use of brief codes of words and phrases to expedite the sending of messages, but this elaboration was not extensive.

Through the course of the Roman empire history has incidental reference to signaling, but no record of marked improvement in methods; and through the middle ages the history of signaling is almost entirely obscure.

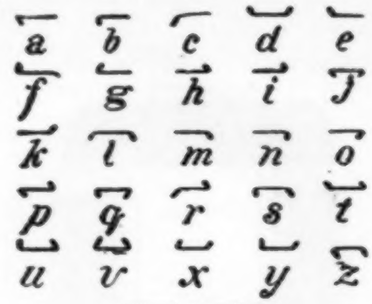
There was, in fact, but little or no material advance until the latter part of the eighteenth century, when the art of signaling received an increasing share of attention, and a growing interest led to the making of many experiments. In France, in 1792, Claude Chappe



CHAPPE'S SEMAPHORE.

perfected a semaphore that marked a great advance in signaling. It was the first apparatus by which long sentences could be transmitted readily, and in a measure it brought the transmission of intelligence by signals to the perfection of a language, for it had an alphabet of its own. Chappe's system was for use by day only. Attached to the upper end of an upright fixed post was a wooden bar fourteen feet long that could be moved on a pivot at its center. Attached to each end of this movable bar was a shorter bar, which also was movable on a pivot. These three movable bars were so geared and connected with a crank by pulleys that they could be moved to and held each at any angle by an operator who stood at the base of the fixed upright post. A miniature apparatus at the foot of the post reproduced the positions of the movable arms, and enabled the operator to adjust them easily and quickly. Chappe's apparatus was called a telegraphe.

The alphabet used with Chappe's apparatus is shown below:



CHAPPE'S ALPHABET.

Chappe's machines were set on housetops, towers, hills, and other elevated points. Each station was provided with telescopes. The distance ordinarily covered between two machines was ten or twelve miles. Long and important telegraph lines were operated by this system by establishing repeating stations. Three words or more were sent in a minute, and by the use of vocabularies and word and phrase signals higher speed was attained. The machines were set close enough together to insure successful operation in ordinary weather, and under exceptionally favorable weather conditions some stations were skipped, thus expediting transmission. Under some weather conditions transmission might be interrupted.

Napoleon extended the lines that had been built under the republic and built new ones to the frontier to connect his armies with the established system. He tried to make use of the Chappe system of signaling in active operations in the field, but it was too cumbersome for such purposes. Napoleon tried other experiments in signaling. He made some use of flags for this purpose, but to what extent or with what results is not definitely recorded. Chappe's system was used in the Crimea, and its use in France was not wholly abandoned until after the Crimean war.

Chappe's success stimulated other inventors, and on all hands efforts were made to devise new methods and to improve and perfect the old methods of signaling. The English were foremost in these efforts. In England was devised for night signaling a system with an alphabet substantially like Chappe's. In this night system, lights were secured to the angles of a triangular frame which turned on a pivot. One fixed light was placed as a point of reference by which the positions of the other lights could be determined. This was the first practical use of the modern night signal. Early in this century there was invented in England a numerical or alphabetical flag system for naval signals. Messages were transmitted by the display of flags of different colors and shapes. This was the system used in 1805 at the great battle of Trafalgar.

The English continued to elaborate the flag system, and Capt. Marryat invented a system that was and is still used in the English navy. Other nations adopted the English system or formed alphabetical or numerical systems of their own. For a time all of these systems were used almost entirely for naval purposes. Then the system was adapted for the use of commercial vessels, and soon the benefits that might attend the use of a system whereby ships of different nations could talk with each other were discerned, and an international code was invented. This code, which was adopted about 1825, makes use of only those letters that are common to the alphabet of all languages. A is the only vowel used. Each nation has a code book in its own tongue, showing also its equivalents in the tongues of all nations using the code. Copious dictionaries of signals arranged on the same plan are used. A system of night signaling by the use of lanterns of various colors was devised for use with the international code. This system was not so wide in scope as the flag system, but it afforded a practical means of communication. Later a great advance in night signaling at sea was made possible by the invention of the portable fires or signal lights now in common use. By means of the international code vessels of various nations are enabled to communicate with one another and with lighthouses and life-saving stations, and with any observer who may be provided with the code.

In the United States, in 1844, Morse brought the electric telegraph into use. The first line was built between Baltimore and Washington. The first formal message sent was, "What hath God wrought!" The use of Morse's great invention spread to all parts of the world, and as telegraph lines were extended they gradually supplanted all other devices for communicating by signals on land. While flags had come into use as a means of signaling on the sea, there had been no flag system in use on the land, and down to 1860 no army of any nation had been provided with an adequate and efficient system of signaling suitable for active operations in the field.

The modern system of military signaling with flag and torch now in general use was invented by Albert J. Myer. It was first used in the army of the United States in 1860. It was soon afterward adopted by all nations that conduct warfare by modern methods.

Albert J. Myer was born in Newburg, N. Y., in 1828. He died at Washington in 1880. He was graduated at Hobart College in 1847. He studied medicine at Buffalo, and was graduated in 1851. His graduating thesis was entitled "A Sign Language for Deaf Mutes." After three years' practice of his profession he was in 1854 appointed an assistant surgeon in the army. In 1860 he was appointed signal officer with the rank of major. He attained the rank of brevet brigadier-general, and after the establishment of the weather bureau he was known as "Old Probabilities."

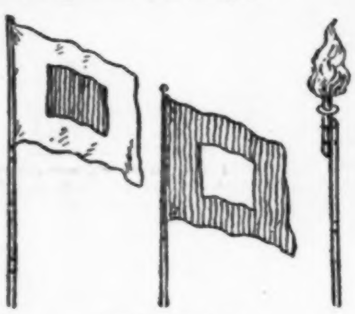
In 1851 Gen. Myer's attention was first attracted to the consideration of signals for military and naval uses. After years of study he evolved a plan of signaling that afforded a simple, sure and rapid means of communication by the use of appliances few in number, simple in operation, and so light that they could

be easily transported and readily used wherever soldiers could go. For the cumbersome fixed apparatuses of the old systems he substituted a flag by day and a torch by night: for the signs of the old systems he substituted an alphabet of motions. The plans were submitted to the secretary of war, and in 1858 a board of officers was appointed to examine them. A favorable report followed. In his annual report for the year 1859 the secretary of war commended the plan to the attention of Congress. An appropriation of $2,000 was made for the manufacture or purchase of apparatus and equipment for field signals, and the law further provided for adding to the staff of the army one signal officer, with the rank of major of cavalry. On July 2, 1860, Assistant Surgeon Myer was appointed signal officer. On July 16, 1860, Major Myer was ordered to report to Col. Fauntleroy, commanding the department of New Mexico, for duty. Later in 1860, in the campaign against the Navajo Indians in northwestern New Mexico, the signal system was first put to its practical test and its usefulness was demonstrated.

First practically tested in a wild country and under many difficulties, the modern system of military signaling was soon to find a far wider field of operations. On May 5, 1861, orders were issued relieving the signal officer from duty in the department of New Mexico, and directing him to report at the headquarters of the army. Communication with New Mexico was not so speedy then as now. Major Myer arrived in Washington on June 3. Officers and men were detailed for instruction in signal duty. The first signal camp of instruction was opened at Fortress Monroe on June 10. On June 26 Fortress Monroe and the detached post of Newport News were placed in communication. That was the first signal service performed in the civil war. In the Confederate army a corps of signalmen rendered effective service at the first battle of Bull Run, July, 1861. The signal system used was that invented by the signal officer of the United States army. The chief signal officer had learned the use of the system while an officer in the Federal service.

While signaling had been to some extent used in directing the fire of guns and in other operations, its first use by the Union forces in actual battle was at Port Royal, S. C., in November, 1861. The value of the services rendered there was attested by both naval and military officers of the combined expedition.

The signal flag first used was all white. Some objection was raised to this because it was thought it might be mistaken for a flag of truce, and it was suggested that it be distinguished by a diagonal bar. It was not then deemed necessary to adopt the modification for that reason, but early in the civil war flags especially designed for signal use were adopted.



FLAGS AND TORCH.

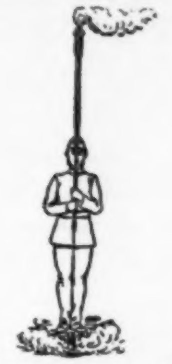
The flags generally used in active operations were four feet square. One was a white flag having at its center a red block sixteen inches square; another flag was black, having a white block at its center; another was red with a white block at its center. The white flag and the red flag were more commonly used than the black. There were provided also a six foot white flag with a red block two feet square at its center, a six foot black with a white block at its center, a two foot white flag with a red center eight inches square, and a two foot red flag with a white center. The square or block was adopted to distinguish the signal flag plainly from all other flags, the colors to afford the greatest degree of visibility by contrast with the background. The white flag was the one most used, being the one most distinctly visible against trees, grass, hills, and the greatest variety of background. The black flag was sometimes used against skies and clouds.

The staff, which was used either for flag or for torch, was made in four jointed pieces, each four feet long and tapering from 1¼ inches at the butt to half an inch at the tip. When the torch was used it was attached to the third joint, which was guarded with brass at its upper end. The tip was attached when the flag was used. With either flag or torch one or more joints could be used as might be convenient or necessary.

The torch was a copper cylinder 18 inches long and 1½ inches in diameter, provided with a close fitting wick and filled with turpentine or other burning fluid. To each torch when in use was attached, near the top, a copper flame shade about two inches wide to prevent the flame from traveling down the side of the torch and overheating it. The torch was attached to the staff by clamp rings and screws. There was provided also a foot torch, similar in construction to the flying torch, but half an inch larger in diameter. In night signaling the form of the signalman cannot be seen at a distance, and it might be impossible for the observer to discover with certainty the direction of movement of the flying torch. The foot torch lighted and placed at the feet of the signalman serves as a point of reference by which the direction of movement of the flying torch can readily be distinguished. Often a small fire kindled at the feet of the signalman was made to serve this purpose.

When the signalman held the flying torch upright, the flame, when not blown by the wind, was eight to ten inches in height. When the torch was waved, it flared into a flame of greater length, making a short trail.

In signaling, the flag and the torch were used in the same manner; by making motions to the right, to the left, and to the front. The staff was held upright in front of the signalman with the flag above his head. Each motion was from that upright position down to the ground or to the level of the signalman's feet if the signaling was done from an elevated place, and then without pause back to the upright position. Ordinarily flag or torch signals could be read by the aid of a field telescope at a distance of ten to fifteen miles.



FLYING TORCH AND FOOT TORCH.

Various codes of signals, all based on the same principle, were devised. The one most used in the army was known as the general service code. In the latest use of this code the flag motion to the right was numbered 1. The motion to the left was numbered 2. The motion to the front was numbered 3. To describe them yet more briefly, the motions were known as signals 1, 2, 3.

In the use of the general service code during the

SIGNALLING AT NIGHT.

civil war the motion to the left was numbered 1, and the motion to the right was numbered 2, both exactly the reverse of the later system of numbering. After the war the numbering was changed, and the 1 was made to the right of the sending signalman, so that it might appear on the left of the field of view of the receiver, where he would naturally look for the lesser number of a series, just as in an alphabet printed across a page we would naturally expect the letter A to appear on the left. The later arrangement is here given. Practically it serves equally well to illustrate the system as used during the war.

An alphabet of numerals was formed, and, as far as possible, so arranged that the letters most used might be signaled with the fewest possible movements. This is the alphabet of the general service code:

A	22	P	1212
B	2112	Q	1211
C	121	R	211
D	222	S	212
E	12	T	2
F	2221	U	112
G	2211	V	1222
H	122	W	1121
I	1	X	2122
J	1122	Y	111
K	2121	Z	2222
L	221	&	1111
M	1221	ing	2212
N	11	tion	1112
O	21		

The end of a word was indicated by signaling motion 3, the front or third motion; the end of a sentence was indicated by 33, two front motions; the end of a message by 333. There were also certain arbitrary arrangements of flag motions representing short and frequently used messages incident to the service, as

FIRST POSITION.

"Wait a moment," and so on, and for other signaling purposes.

In signaling, the flag was first waved from side to side until the attention of the station to be signaled to was attracted. Then the signalman held his flag upright, and the signal officer began to read the message to be signaled, by words if the signalman were expert, or by letters or motions. The motions are shown below:

FIRST MOTION—1.

It should be understood that when the sending of a letter has been begun, the movement of the flag must be continued without pause until all the motions necessary to indicate the letter have been made. When the flag stops in the vertical position it indicates that the letter is completed. Thus, to signal I, which is indicated by 1, that is, by one first motion, the flag is waved once to the right and then back to the first position and held there.

SECOND MOTION—2.

To make O, which is indicated by 21, the flag is waved once to the left and once to the right, and then to the upright position, without any pause from start to finish.

2—1, 21.

To make P, 1212, the flag was waved right, left, right, left, and back to vertical, all without a pause. D, 222, was made by three left motions following each other without pause until, after the third motion, the flag was held upright and at rest, indicating the end of the letter. A pause of one or two seconds was made between letters. Take, for example, the word "the." To make *t*, which was indicated by 2, the flag was waved once to the left and then brought back to vertical and held there for a moment. To make *h*, which was indicated by 122, the flag was waved once to the

1—2—1—2, 1212.

THIRD MOTION—3.

right and then over to the left, up to the vertical and down to the left again, and up to vertical and stop, all the movements from the beginning of the letter until the finishing of it having been without pause. Then, after holding the flag at the vertical position for one or two seconds, the sending of *e*, 12, was begun. Wave to the right once, then clear over to the left once, and then back to the vertical position and stop. Then, finally, the front motion, 3, was made to indicate the end of a word, and the sending of the next word was begun.

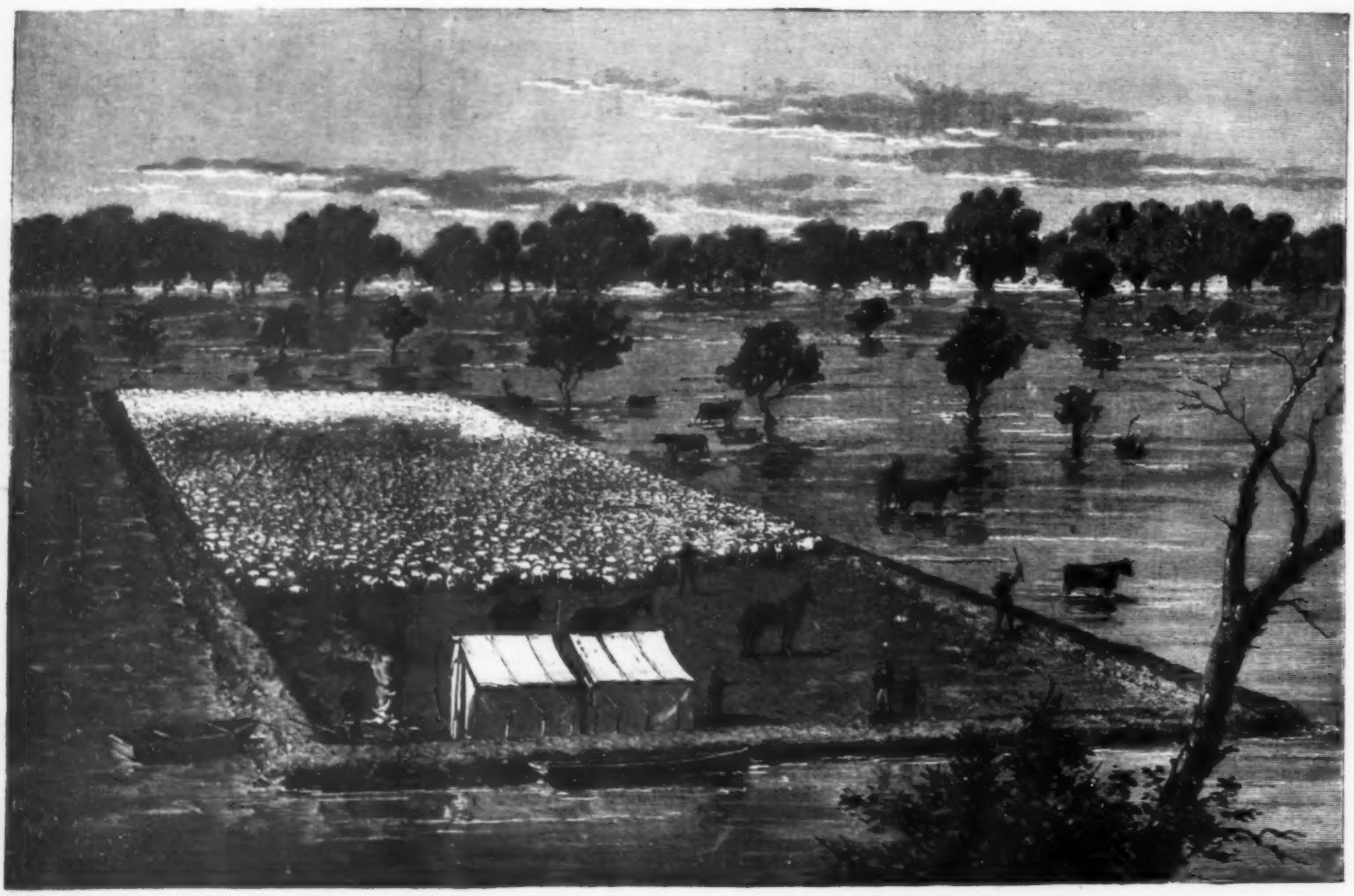
It will be apparent that by this plan of signaling

messages could be sent by a great variety of means of communication. Within short distances a man could signal by waving a handkerchief, or by making motions with his arms or with a stick, or at night by motions with a lantern or a firebrand. Messages may be communicated by winking the eyes or by tapping the feet. It is an old story, but one that keeps well, that of the two signalmen or telegraph operators who, at a hotel table, sat near another man who was accompanied by a very pretty young lady. Gently tapping the handle of his knife on the table, one of the signalmen said to his companion, "Goodness, what a pretty girl this is next to me." They quickly discovered that the other man understood signaling, too, for he promptly ticked out with his knife: "You are right, boys, but this lady is my wife." Thereupon all signaling ceased.

(To be continued.)

FLOODS IN AUSTRALIA.

THOUGH drought is sometimes the worst disaster on Australian sheep runs and cattle runs, occasional destructive floods, in certain localities, may imperil a large amount of pastoral property. We are furnished with an illustration of the energetic measures taken by Mr. J. S. Gordon, manager of the Brewon station, near Walgett, by which many thousands of sheep and bullocks were saved, during the floods of last April, in New South Wales. He rapidly constructed a dam around the homestead, and gathered nearly the whole of the live stock within its protection. When the inundation was at its height, the nearest dry land was twelve miles distant. Only twenty head of cattle and under 250 sheep were lost. Walgett is a town in the sheep country of the Salt Bush, on the upper Darling River, about 470 miles northwest from Sydney. The Brewon station, at which the dam was constructed and the stock were saved, is a portion of the large station belonging to Messrs. Mackay Brothers. It is surrounded by the Castlereagh, Macquarie and Barwon Rivers, the last mentioned river being the most considerable affluent of the Darling. In the *Australasian* there is a particular account of this affair.—*Illustrated London News.*



FLOODS AT THE BREWON STATION, NEW SOUTH WALES, WITH DAM ERECTED TO SAVE CATTLE AND SHEEP.

IS THERE LIFE AMONG THE STARS?

ONE of the most fascinating questions that astronomical discoveries have ever raised is whether planets revolve in the light of all or any of the millions of stars scattered through space. It has been demonstrated that many, and probably most, of the stars are suns greater by far than our sun as givers of both light and heat. Mr. Lockyer's speculations as to the meteoritic origin of the celestial bodies may lead us to think that many of the stars are, as yet, merely clouds of meteors and not truly solar bodies, but this does not alter the fact that their luminosity exceeds the sun's, or that no matter what their present condition may be, they will ultimately reach a stage of development closely resembling that of the sun. If the stars are meteor born, so is the sun. And if the great majority of the stars are as yet only condensing swarms of meteors, then we are led to the most interesting conclusion that the universe taken as a whole is in its infancy rather than its adolescence, much less its dotage.

It is common to hear people speak of the possibility of the stars being inhabited. This can only be granted upon the supposition that the inhabitants dwell on planets revolving around the stars, for modern studies of the sun have completely upset Herschel's idea that the heat and light of the solar orb come to us from an envelope of fiery clouds surrounding a cool and habitable globe. It is not easy to resist the simple argument from analogy in favor of the existence of such planets, especially if we admit that the same laws of development which produced our solar system are in operation throughout space. Recent discoveries of spiral nebulæ, closely resembling in aspect some of the stages of existence through which the sun's system must once have passed if the nebular hypothesis is well founded, greatly strengthen this view of the case. The phenomena of double and multiple stars not only furnish evidence of the extension of the law of gravitation to other systems, but demonstrate the existence of stellar assemblages whose members sustain to one another relations similar to those which bind our planets to the sun.

Still there has been hitherto no discovery of any body that could properly be called a planet revolving around any of the stars. The well known double stars are simply pairs of suns, each shedding its light and heat upon the other, while both revolve around their common center of gravity. In the case of triple stars we find something closely analogous to the phenomena presented by the sun, the earth, and the moon. The moon revolves around the earth, and the earth, carrying the moon with it, revolves around the sun. Just so in a triple star system we behold one star revolving around another, and the two together revolving around a third. The resemblance goes even further, for the smallest star of the three revolves around the second in size, and that in its turn around the largest. Another step, however, and the analogy breaks down, for the earth and the moon are opaque bodies simply reflecting the light of the sun, while all the members of a triple star system are solar orbs. Moreover, the earth and the moon are practically almost infinitesimal in magnitude as compared with the sun, while the smaller stars in the triple systems are comparatively large bodies. In the matter of distance, too, there is a wide difference, the components of multiple stellar systems being generally separated from one another by far greater distances than that of the earth from the sun.

But some recent discoveries are calculated to awaken the hope that we shall eventually obtain at least a partial solution of the question of the existence of planets in the sidereal systems. The spectroscope, which has achieved so many wonderful things for the astronomers, has again proved their friend in this case, and, aided by photography, has detected the existence of double stars so close that no telescope could possibly separate them to the eye. More than that, some of the stellar doubles thus discovered consist of a luminous star and a non-luminous one. We have but to adopt a different phraseology, suggested by analogy, and these strange couples are presented to our minds as sun and planet.

Perhaps the most remarkable of these interesting doubles is the celebrated star Algol, the periodic variations of whose light have been known and watched for centuries. Prof. Vogel's spectroscopic investigations indicate that there is a dark body revolving around the star in a period of less than three days, and at a distance of about 3,250,000 miles. According to computations based upon the data obtained by Vogel, the diameter of Algol is 1,116,000 miles, or 256,000 miles greater than that of our sun, while the diameter of its strange companion, or satellite, is 840,000 miles, being 20,000 miles less than the sun's. But the density of these huge bodies is singularly slight, so that their combined mass is only two-thirds as great as that of the sun. From this it is easy to see that the dark member of the system, the planet if we may so call it, is more than a million times as large as the earth, and about 50,000 times as heavy. There is one consideration, independent of its slight density, which would seem to dispose of the possibility that this strange planetary consort of Algol can harbor living beings. If we assume that Algol's radiative energy equals the sun's, then it must overwhelm its attendant orb with a gush of heat 900 times as intense as the solar heat that is poured upon the earth. This results from the fact that the distance of the dark companion from Algol is only about one-thirtieth of the earth's distance from the sun, while the intensity of light and heat varies inversely as the square of the distance.

Another star that has a close companion which, although itself invisible, reveals its presence by the effects of its attraction upon its brilliant neighbor, is Spica, the leader of the constellation Virgo, and one of the most beautiful stars in the heavens. Here there is no such eclipsing of the light of Spica by the dark attendant as occurs with Algol, and the data thus far obtained are far less complete than those of the last named star. It would seem, however, that in this instance also the planet, if planet it be, is of enormous dimensions and revolves very close to its primary, the distance being estimated at from 3,000,000 to 6,000,000 miles. Rigel, the splendid twinkler in the left foot of Orion, has also given indications that it has a close and invisible satellite of as yet unknown dimensions. It has long been known that Procyon, another first magnitude star, has an invisible companion, and with the new methods of research something may be learned of its size and distance. We do not here refer to the recent discoveries concerning Mizar in Ursa Major, and Beta Aurigæ, because the companions of those stars, situated at distances of 140,000,000 miles and 8,000,000 miles respectively, are luminous bodies, and consequently cannot resemble planets in their present physical condition, although the doctrine of celestial evolution teaches that eventually they may pass from the solar into the planetary state by the exhaustion of their radiations.

It will be noticed that in every case the dark bodies discovered among the stars, which, by a stretch of the imagination, may be likened to planets, are of great magnitude as compared with the planets of our solar system. This may not be as serious an objection to their habitability as their nearness to their primaries is, and yet, according to our terrestrial experience, a globe 50,000 times as heavy as the earth and a hundred times as great in diameter would make a strange abode. On such a globe an average son of Adam would weigh not less than 700 or 800 pounds, unless his dimensions were proportioned to the intensity of gravity, in which case he would be only between a foot and fifteen inches tall. It is more agreeable, however, to suppose that some unthought of peculiarity in organization, such as the slight density of the planet readily suggests, would enable the man to be at the same time imposing in stature and graceful and agile in movement, for the imagination finds something repugnant in the idea of a race of lively pygmies constituting the population of a planet of the most majestic proportions.

At no time in its history has the outlook for astro-

nomical discovery been more promising than it is at present so that one can hardly be too sanguine in expecting that these recent advances, which have partially lifted the veil from the inner mysteries of the starry systems, are but preludes to still more interesting discoveries which may reveal the existence of unmistakable planets rejoicing in the light and smiling with life as our earth rejoices and smiles.—*New York Sun.*

BUFF COCHINS.

OUR illustration is that of Matchless, a superb buff Cochin cock, the property of Mrs. Scriven, England, the lady who had the two buff Cochin cocks at the New York show last winter, which were sold at $150. The *London Stock Keeper* has published an illustration of this splendid bird, with an account of his success in the show room. We reproduce the cut in this issue to show our readers the type and excessive feathering which has been for several years so very popular in England, notwithstanding the protests from American and Australian Cochin fanciers.

Matchless was hatched late in 1887, his grandsire being the celebrated Lord Watford, about which bird there was a great deal of correspondence. To give some idea of his size and massive appearance, we may state that his height is two feet, that the width from toe feather to toe feather is eighteen inches, and that his weight when fifteen and a half months old was nearly twelve pounds. His color and shape are excellent, and he is as active and sprightly as a cockerel. He has only been exhibited at five shows, with the following results: First at Huddersfield, under Mr. Beldon; first at Palace, under Mr. Dixon; first and cup at Birmingham, for the best cock or cockerel in the show, by Mr. Comyns; first and cup at Manchester, by Mr. W. Birch; and first and cup at Southport as the best Cochin in the show, under Mr. Nichols.

English fanciers have been very enthusiastic in bringing the buff Cochin to its present massiveness and beautiful color. The buff is one of the oldest varieties of the Cochin family. The Queen of England's first importation, though of a different type from the present bred buffs, and being also clean shanked or very sparsely feathered, were in the main reddish buff. The importations of Messrs. Sturgeon & Moody were buff, from which birds they raised some grand specimens. English fanciers being free from any disturbing influence, were first to pursue a steady and direct line of breeding to color and type, bringing order and uniformity out of the diversified types and colors which came from the original importations, while the American fancier was environed and quite restrained by the sudden appearance and popularity of the Brahma, which gave every indication it would eclipse, if not check, the enthusiasm and emulative spirit manifested in the Cochin class.

The importations to this country from China, however, exceeded those to England. From 1846 to 1850, we had the Brown, Marsh, Forbes, Cushing, Cope, Palmer and Burnham birds; though it was some years later before any regular classification took place in the show room, still there arose sharp competition between the pioneer fanciers in buffs and partridges, the different importations showed recent crossing, though buff and partridge colors led, but from the stock were bred white, buff, gray, lemon, red, cinnamon, drab, brown, bronze partridge, grouse, and black birds.

We have in this country, grand specimens of buff Cochins. In some respects they are superior to the English bred birds. The American birds are, as a rule, faultless in symmetry, and have enough of fluff and leg feathering to perfect their contour. The buff is the ideal and true type of the Cochin as universally conceded, but the excessive feathering of the English bred birds gives them massiveness at the expense of fullness of breast, and awkwardness in breeding, sitting and brooding the young. Such excessive feathering has become hereditary, and a large per cent. of vulture hocks, to a development that one might justly style "winged," is the inevitable consequence. Very few of our leading fanciers like the English buffs on this account. And when they do purchase some to add fresh blood to their stock, they demand specimens which do not show the excessive feathering which is the pride of the English buff fancier. It has been proved many times that excessive feathering is detrimental to a well balanced organism. English fanciers go to extremes in breeding; massiveness is a national trait, which governs their taste in breeding as well as in construction, while the American fancier's taste is uniformity, type or symmetry. In color and facial points, the English buff is all the most fastidious fancier can wish for, nothing in the make up, except excessive feathering and excessive weight is objected to, but for usefulness either extreme is injurious to the best interests of the buff Cochin.

There is something in the buff Cochin which commands the admiration of the non-fancier as well as the fancier. They are invariably massive, even in size, constitutionally robust and hardy, active on foot for a large fowl, quiet, lovable and very domestic in habits. No standard breed in the exhibition room will score so evenly, no standard breed will compete so closely for prizes, it is no rare thing to see the fractional part of a point decide the award, no standard breed taxes the skill of the judge so critically, and no standard breed excels them in attractiveness in the show room.

It is conceded by artists of nature and natural groupings, real connoisseurs of landscape harmony and beauty, that a flock of buff Cochins on a green lawn is one of the most harmonious and picturesque sights that can be desired. The rich gold color, not the pale and faded buff, is ever in harmony with green, and is suggestive of richness. Of course the massive size of the buff Cochin, the abundant feathering and faultless type, rich red comb, face and wattles, have much to do with increasing their attractiveness, much more than in small fowls of the same color. The hens too, being only a few shades lighter, as graded by painters, the harmony is made more conspicuous.

MRS. SCRIVEN'S BUFF COCHIN COCK.

From the shell, the buff is pretty and interesting. One can see in its downy covering the future color. There is no grizzly gray, black and white, cloudy white, spotted, or zebra-like stripes, but downy balls of yellow fleece or worsted, with a sleek, neat head and two beaded eyes, so mild, innocent and confiding. Their looks do not belie them, for they have not the wildness, mischief making, or the low, cunning ways of some small breeds. The buffs are not first-class layers, but otherwise they are well worthy of a more extended cultivation.—*Poultry Monthly.*

THE MOST VOLATILE CONSTITUENTS OF COAL TAR.

IN their investigations of the most volatile portions of coal tar, authors have hitherto employed the runnings obtained by the distillation of benzene hydrocarbons which have been subjected to a preliminary treatment with acids and alkalies. On this account a number of substances present in the crude material have escaped identification, owing to their removal by this treatment, while new bodies formed by the action of acids and alkalies have been isolated which could not be detected in the raw material, and it is undoubtedly owing to this circumstance that conflicting statements have been published regarding the presence or absence of a number of substances in the most volatile portions of coal tar. The author therefore thought it desirable to employ unrefined benzene hydrocarbons for the purpose of this investigation, special attention being also given to the quantitative determination of the more important constituents by simple and accurate methods. At first the portion of English 90 per cent. benzene boiling between 30° and 80° was used, of which about 1·5 per cent. was obtained. Subsequently the fractions boiling between 50°–60° and 60°–70° were chosen, the necessary material being obtained from Haussermann, of the Griesheim Chemical Works, and the fractions being marked L 1 and L 2 respectively. They form colorless mobile strongly refractive liquids (assuming a yellow color on standing), and possess a disagreeable penetrating odor which causes headache and slight giddiness after prolonged inhalation. The taste is caustic. Blue litmus paper is turned red. They burn with a luminous smoky flame which gives off a disagreeable odor. All attempts to isolate the different constituents by fractional distillation were unsuccessful; thus the fraction L 1, which gave about 66 per cent. between 50° and 60°, began to boil at 40°, and left a considerable residue boiling above 60°, and although after several fractionations it was possible to gradually concentrate the carbon disulphide in the portion boiling below 50°, the results were by no means satisfactory, as this end could only be achieved at the expense of the higher boiling portion. It would, in fact, seem as if it were not merely some peculiar property brought about by the process of fractional distillation which gives rise to this anomaly, but as if during the distillation the mixture suffered decomposition, forming new substances which considerably influence the boiling point. The author therefore tried the following methods: He attempted to remove by some means the bodies known to be present and then searched for new substances, and in the second series of experiments he made a number of tests to detect the presence or absence of certain hydrocarbon series by means of well-known group reagents.

1. Carbon disulphide was first obtained by Vincent and Delachanal from the low boiling portions of unrefined benzene. Its presence completely masks the results obtained by fractional distillation, and as acids and alkalies fail to remove it, commercial benzenes are almost invariably contaminated therewith. For the quantitative determination, Hofmann's process was tried. This is based on the formation of a well crystallized red additive compound when carbon disulphide is brought in contact with triethylphosphine. The author used pure carbon disulphide boiling at 46·8°, but failed to obtain satisfactory results, although he is unable to explain the cause of this. The numbers were invariably too low. He then tried the xanthic acid reaction. For this purpose, a measured quantity of carbon disulphide or liquid containing the latter is added gradually to an alcoholic solution of potash, when potassium xanthate is formed. The amount of the latter is then estimated as cupric xanthate, by adding a decinormal solution of cupric sulphate until there is a slight excess of the copper salt, which is ascertained by placing a drop of the solution from time to time on a double filter paper, and testing the liquid on the lower paper with potassium ferrocyanide. One c. c. of the copper solution is equal to 0·0152 gramme of CS_2. The method gives good results. The following numbers are obtained:

	Per cent. CS_2.
Fraction boiling between 30° and 80°	57·30
Fraction L 1	19·80
Fraction L 2	19·17

The amount of potassium xanthate may also be estimated by means of a standard iodine solution. The author, however, found that with pure carbon disulphide, the results were about 2·5 per cent. too low. In order to remove the carbon disulphide, the following method was adopted: From 1,000 to 1,200 grammes of first runnings are placed in a flask and treated with from 5 to 6 times the weight of alcohol, the flask and contents being kept in a cooling mixture to prevent loss by evaporation. A constant stream of dry ammonia is then introduced through a wide glass tube, until the separation of solid xanthate is complete, when the mixture is filtered rapidly through a cotton filter, the filtrate being collected in a separating funnel. The lower layer contains the alcohol, some water and a small amount of hydrocarbons in solution. In order to separate the latter, the mixture is diluted with water, the product thus obtained is then added to the upper layer and the whole subjected to another treatment with alcohol and ammonia. It is advisable to repeat this operation a third time, in order to insure the complete removal of all sulphur compounds. The hydrocarbon liquid is then washed thoroughly with water and dehydrated with calcium chloride. The removal of carbon disulphide reduces the specific gravity considerably; thus in the case of fraction L 1 it fell from 0·8148 to 0·7401.

2. Nitriles and Isonitriles.—Vincent and Delachanal found acetonitrile in light benzene to the extent of 50 to 70 per cent. Noetling detected the presence of an isonitrile, and showed that in spite of the small proportion of poisonous ingredients found in the first distillation from benzene, the working of light benzenes on a large scale may under certain conditions produce poisonous effects. He quoted a fatal case which occurred at a factory in Thann, where a workman, having inhaled the vapor of isonitrile, died from its effects. For the quantitative estimation of nitriles the author used the following method: A measured quantity of light benzene was boiled in a flask provided with a reflux condenser for 12 to 15 hours, with half its weight of concentrated hydrochloric acid. The brown mass thus oxidized was evaporated to dryness, extracted with hot water, the solution filtered off, again treated with hydrochloric acid, evaporated and extracted with water. The operation was repeated until the residue was colored only slightly yellow. It was then dissolved, treated with hydrochloric acid, evaporated to dryness in a tared dish, dried at 100° and weighed. The following results were obtained:

	Per cent. nitrile.
Light benzene boiling between 30° to 80°	7·49
Fraction L 1	11·93
Fraction L 2	10·06

3. Aldehydes and Ketones.—From the circumstance

that aqueous solutions extracted from light benzene reduce ammoniacal silver solutions, the author concludes that aldehydes are contained in the first runnings from benzene. He treated a large quantity of fraction L 1 with sodium bisulphite, but obtained only about 1 per cent. of extract, and was, therefore, unable to examine the mixture of aldehydes and ketones more closely. He, however, detected the presence of acetone by the characteristic odor, the formation of iodoform and the indigo reaction with orthoditrobenzaldehyde and sodium hydroxide. According to Michael, a bright resinous substance is obtained on boiling aldehyde with an alcoholic solution of resorcinol and a minute quantity of hydrochloric acid (see this *Journal*, 1884, 253). The author has obtained a similar product by applying the same reaction to light benzene.

4. Ethyl Alcohol.—The author has not been able to isolate this product from any of the fractions obtained by the distillation of light benzene. He, however, obtained a faint reaction of ethyl alcohol from a sample which had been in contact with water for a fortnight, and concludes from this result that light benzene contains an ethyl compound which is gradually decomposed by water with formation of ethyl alcohol.

5. Phenols.—The examination for phenols was conducted in the following manner: After treatment with hydrochloric acid the light benzene was shaken up with dilute soda lye. The alkaline extract was then acidified with sulphuric acid and distilled with steam or extracted with ether. In both cases a product having a tarry odor was obtained, but the quantity was too small to admit of further investigation.

6. Mercaptans.—To detect the presence of these compounds in light benzene the different fractions were heated with mercuric oxide and alcohol, and in a second series of trials they were added to an alcoholic solution of mercuric chloride. The presence of mercaptans could not, however, be established with certainty, as only a slight turbidity was obtained.

7. Detection of Bodies belonging to the Pyrol, Thiophen and Furfuran Series, also of Hydrocarbons of the Benzene Series.—The vapor from fraction L 1 imparts a greenish color to pine shavings moistened with hydrochloric acid. The reaction with the phenanthraquinone and with isatin and concentrated sulphuric acid gave no coloration, so that it may be inferred with certainty that no closed chain compounds of the pyrol, furfuran, or thiophen series are present. It is not possible to separate aromatic hydrocarbons by treatment with a concentrated solution of picric acid, although benzene was found in the residue obtained by fractional distillation.

8. Unsaturated Compounds.—The different fractions from the light distillation of light benzene absorb bromine very eagerly, and form additive as well as substitution compounds. The group of unsaturated compounds includes derivatives of acetylene, the author having found that on adding ammoniacal solution of cuprous chloride to light benzene and allowing the mixture to stand, a red-brown precipitate is obtained. —*Dingl. Polyt. Jour.*; *Chem. Trade Jour.*

THE UNBURNED GASES OF GAS STOVES AND BURNERS.*

I HAVE been working for some time with a view of determining whether the gases escaping as flue gases from gas stoves and different burners were really free from gas capable of combustion, such as carbon monoxide, or unburned hydrocarbons or hydrogen. I spent some time in trying to separate and determine the quantity of carbon monoxide present, if any, but this problem was beset with so many difficulties that for the moment I abandoned it and contented myself for the present with determining the quantity of unburned carbon and hydrogen in whatever forms these might exist. For this purpose I arranged an apparatus consisting of two carefully weighed U tubes filled with strong sulphuric acid, and two weighed U tubes filled with soda lime, through which the flue gases were first passed. These absorbed the water and carbon dioxide contained in the flue gases, leaving the hydrocarbons (not absorbed by vitriol), hydrogen and carbon monoxide to pass through a red hot glass tube filled closely for 15 in. with oxide of copper, prepared *in situ* from copper wire gauze. The gases were then passed through strong sulphuric acid and soda lime contained in previously weighed U tubes, and the results were calculated on the gas measured at 60° Fahr. and thirty in. barometric pressure, from the measure of gas drawn into the aspirator (treated as water-saturated gas). The carbon dioxide and water vapor absorbed in the tubes were then added on to make up the measure of flue gas originally employed and which was taken for the determinations. The coal gas employed was previously passed through large cylinders filled with calcium chloride to dry it before combustion, and at the same time as the experiment was going on, and side by side with it was estimated the carbon dioxide and water vapor present in the air itself by passing it by means of another respirator through strong sulphuric acid and soda lime in U tubes previously weighed.

The carbon dioxide in the air itself ranged from 0·41 to 0·66 grain per cubic foot of air, and *the water* from 3·51 to 7·23 grains in the same volume. The amounts of carbon dioxide and water collected from the flue gases, after deducting the quantities actually present in the air, were taken as those due to the combustion of the coal gas. The standard I employed was one used by Professor Roberts-Austen in his analysis of the flue gases from the burning of coal, and the apparatus employed was generally similar to that also employed by him. The carbon and hydrogen left unburned were measured in terms of 1,000 parts of carbon, actually derived from the combustion of the gas in the stove or burner. The total quantities of carbon dioxide and of water in the flue gases amounted to from 6·6 to 10·8 grains per cubic foot for the former and from 5·6 to 10·5 grains of the latter, in the same volume.

The amount of flue gas passed in each experiment was about one cubic foot, and although the variations were considerable, the general results were conclusive in showing that the combustion of gas, when burned in gas stoves for heating purposes, is much more incomplete than one might be led to suppose.

The only burner in which the weights of the tubes remained constant after passing the burned gas, and in which the combustion was presumably complete, was in a paraffin oil lamp in which the flame was not turned to its highest point. In another experiment with the flame turned full on, 12·04 and 3·09 respectively of carbon and hydrogen escaped combustion per 1,000 of carbon completely burned.

The next nearest approach to complete combustion was in an Argand burner, in which all the carbon was completely burned, but an amount representing 0·2575 part of hydrogen escaped combustion per 1,000 parts of carbon completely burned, while in a second experiment 0·113 of carbon and 2·5414 of hydrogen escaping combustion were registered per 1,000 parts of carbon completely burned. Then came one of Bray's ordinary flat flame burners, burning four cubic feet per hour, which gave 11·12 of carbon and 0·95 hydrogen unburned per 1,000 of carbon completely burned.

Following in order these results came the Welsbach light, in which the gas heats to whiteness a tube or mantel composed of a filmy thickness of the oxides of zirconium and titanium, the mantel being surrounded by a glass tube similar to that used in some paraffin oil lamps. In this case the unburned carbon exceeded in amount the unburned hydrogen, there being 15·486 of the former and 3·794 of the latter per 1,000 of completely burned carbon.

Three experiments were made with a Marsh-Greenall's heating stove, in which three Bray's luminous burners were employed. The first was made with a consumption of 5·62 cubic feet of gas per hour, when 12·6 and 3·0 parts of carbon and hydrogen respectively were registered per 1,000 parts of carbon completely burned.

The second experiment, with a consumption of 5·74 cubic feet per hour, gave 37·6 and 11·8 respectively of carbon and hydrogen unburned. The third experiment, with an increased consumption of gas (7·1 cubic feet per hour), gave 97·4 and 12·1 of carbon and hydrogen respectively unburned.

Two experiments were made with one of Mr. Thomas Fletcher's heating stoves, in which eight Bunsen burners play upon some fancy metal work (iron coated with magnetic oxide). The one experiment in which the amount of gas passing was not measured gave 43·3 of carbon and 24·6 of hydrogen unburned per 1,000 of carbon completely burned. In the second experiment, where 6·81 cubic feet of gas were burned per hour, 66·3 and 20·0 respectively of carbon and hydrogen unburned were registered.

One experiment was made with one of Mr. Fletcher's stoves, in which twenty Bunsen burners play on asbestos projecting from a fireclay back, with a consumption of 8·14 cubic feet of gas, 138·9 and 11·7 parts respectively of carbon and hydrogen per 1,000 parts of completely burned carbon were found.

In a stove in which the hot gases rise to the top of a cylinder filled with pipes (through which cold air passes to be heated), and from the bottom of which the burned gases escape after having cooled to a considerable extent, upward of 200 parts of carbon escaped combustion per 1,000 parts of carbon completely burned.

* Read by Mr. William Thomson, F.R.S. Ed., F.C.S., before the Chemical Section of the British Association.

CORRECTING IRREGULARITIES OF THE TEETH.*

By V. H. JACKSON, M.D., D.D.S., New York, N. Y.

THERE have been presented to the profession by dental specialists from time to time new systems for correcting irregularities of the teeth. Each has received more or less attention, and some of them will continue to be of service as long as irregularities need correction.

Orthodontia will no doubt eventually become a distinct specialty of dentistry, but it is necessary at present for the general practitioner to be more or less familiar with the systems in use, in order that he may choose that which will be the most effective in a given case and require the least outlay in construction. It is my purpose in this brief paper to describe and demonstrate with models and apparatus some methods of applying removable springs without the use of a plate for regulating teeth, describing methods that I am using daily, and with which I have attained good results in a limited time, and in passing I desire to express a growing confidence in the use of the removable spring for moving teeth. Piano wire is at present the best spring for the purpose, although spring gold, silver, and German silver are often applicable, especially if the temper is not drawn while soldering, and that can be avoided in some cases by keeping the spring portion cool, or by using soft solder, which is usually preferable.

The difficulty experienced in regulating the teeth of the lower arch often prompts the dentist to delay the operation from time to time, and more often to avoid even its consideration.

I have been using for a considerable length of time, as is known by some of the gentlemen present, metal spring appliances that are also applicable for the correction of irregularities of the teeth in the lower arch, cases of which I shall first briefly describe.

Fig. 1.—In the model here presented it will be seen

FIG. 1.

that the right inferior cuspid was much too prominent and articulated outside of the upper teeth, there being insufficient space for it in the arch.

The first molar was extracted, as it was defective, and a piano wire was formed to the lingual side of the teeth in the arch, following the line of the gum to the distal tooth on either side, around which the ends were formed to clasp. The gum was very prominent just back of the molars, and accordingly the plaster model on which the appliance was formed was then carved slightly to allow the spring to more perfectly clasp about the necks of the teeth.

A second spring wire was then formed to join the one described, and pass just in front of the second molar through the space made by the extraction of the first molar, and extend forward, terminating in a curve on the anterior surface of the prominent cuspid.

The two spring wires were then joined with soft solder, having first wound the part forming the joint with small copper wire. The whole appliance can, if desired, be plated by immersion in melted tin.

The pressure of the spring was regulated by bending it toward or from the main wire, and by curving the end. The tension was such as to draw the cuspid and and bicuspids backward, and move the cuspid into proper line within a month's time.

A variety of methods have been adopted to keep this form of appliance from pressing on the gum and slipping off from the teeth. Some of these have been published.

The principal forms were wire points soldered to the main wire and reaching into the spaces between the teeth to keep the appliance from slipping off and a similar wire extended on to the grinding surface, usually at the junction of two teeth, to keep the fixture from pressing on the gum.

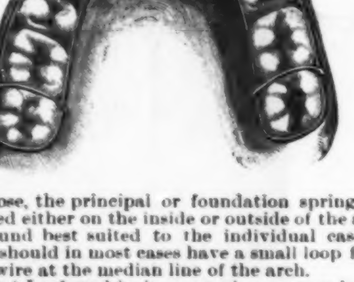
This system has proved to be, for a certain class of cases, the most rapid in moving the teeth, and of the least inconvenience to the patient and operator of any yet used.

The inner bar can be stiffened at any place desired by winding with binding wire, and flowing over it tin or soft solder, or an extra wire can be added in a similar manner at any stage of the operation.

A spring can extend from the main wire to either side of the arch to move teeth out into line, or to the labial side of the arch to force prominent teeth back to a proper position, or be adapted to rotate one or more incisors by pressing them against the main wire.

Fig. 2.—The arch can be easily expanded in many cases with a similar spring appliance. When used for

FIG. 2.



that purpose, the principal or foundation spring can be arranged either on the inside or outside of the arch, as it is found best suited to the individual case, although it should in most cases have a small loop formed in the wire at the median line of the arch.

This point I referred to in a previous paper in the *Dental Cosmos*, vol. xxix, p. 373, describing a method of spreading the anterior part of the lower arch with a plate without covering the teeth. The same wire should extend back along the line of the necks of the teeth and clasp around the last one in the arch, and continue forward usually to the mesial side of the first bicuspid, and there extend over the grinding surface and be soldered to the original wire, which will keep the appliance from pressing on the gun, and also clasp the teeth firmly.

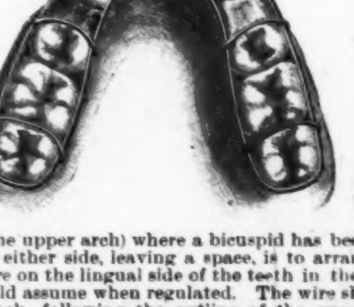
The opening of the median line loop from time to time will spread the bicuspid portion of the arch. The incisors can often at the same time be moved outward into line by the foundation spring, by opening the loop and shaping the spring to press against them. For this purpose the spring should not be too stiff.

One or more additional loops of wire may pass over the grinding surface at the junction of two teeth and be united to those on either side, if the appliance is not otherwise well retained.

This device for attaching apparatus to the teeth I have termed a "crib," a more minute description of which will be given further on.

Fig. 3.—An effectual method of drawing too prominent or overcrowded lower teeth into proper line (as well as

FIG. 3.



those of the upper arch) where a bicuspid has been removed on either side, leaving a space, is to arrange a spring wire on the lingual side of the teeth in the line they should assume when regulated. The wire should extend back, following the outline of the gum, and again forward on the labial side, forming a crib as described, except that the ends should be left free to form

* Read before the International Medical Congress at Berlin.—*Dental Cosmos.*

springs which extend forward on the labial side of the teeth, beyond the median line, thus passing each other.

By the inward pressure of the springs the teeth are forced against the main wire and thus drawn into proper line. It is remarkable that the pinching pressure exerted on the teeth embraced between the inner and outer spring wires squeezes the teeth also to the right and left as if they were being directly pushed backward along the curved inclosure of the crib, which thus simultaneously compels and controls the movements of the teeth in the desired directions.

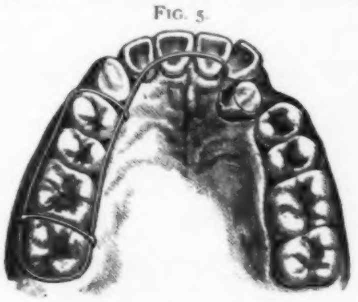
If the front teeth are not prominent enough, as seen in Fig. 4, the appliance should be made the same as

FIG. 4.

the one last described, except that the main wire should be arranged on the labial side of the teeth and the springs on the lingual side, to press the teeth out into the circle made by the main wire in front of them.

Fig. 5.—A "crib" for one side of the arch, with a spring wire passing across to the opposite side, provid-

FIG. 5.



ed with a partial clasp fitted to the tooth to be moved and soldered to the wire end, is efficient in some cases for pressing into line a cuspid or other tooth that is inside of the arch.

A similar crib can also be arranged on either side of the arch and the two be joined by a small spring wire, to which can be attached a T piece to draw back prominent incisors, as in the V shaped arch, and at the same time spread the anterior part of the arch by having the spring press against the lingual side of the teeth that are to be moved outward.

I now present the model of the teeth of a lady thirty-six years old, all of whose upper front teeth closed inside the lower ones.

It will be seen that one lateral incisor and bicuspid and three molars are missing, some of them having been extracted years ago with the hope of correcting the irregularity. But the teeth had crowded together and the articulation became so changed as to give an unpleasant expression to the features. Besides this, the labial surfaces of the superior incisors were becoming worn.

The second model was made from an impression taken while the apparatus was in the mouth, and shows the method adopted for forcing the teeth forward.

The difficulty that is often experienced of moving nearly all of the oral teeth in one direction was very marked in this case, as will be seen by the models.

A crib was made for each side of the arch, to encircle all of the teeth back of the incisors; a slight separation was made by wedging in front of the cuspids, and a round iridio-platinum wire was flattened to pass into the space on either side, and extended back, following the line of the gum and surrounding the cuspid, bicuspids, and molars. This was supported and made to more firmly clasp the teeth by making cross bars to connect the two sides of the crib by passing over the articulating surface at the junction of the teeth, serving also to keep the crib from pressing on the gum.

There was a loop soldered to the crib wire opposite the palatal surface of the first molar on each side of the arch, into which loop was hooked the end of a piano wire formed like the letter S, and extended forward, passing just back of and following the curve of the incisors. There were placed on the incisors gold collars with lugs soldered on their palatal surfaces, to hold that portion of the spring in position.

FIG. 6.

Fig. 6 shows the device in place on the four incisors in another completed case of the same character.

Pressure was made as needed, by straightening the S loops of the spring wire a little at a time.

The incisors were moved rapidly, and when sufficiently forward the portion of the crib in front of the cuspids was removed, and a piece of piano wire was soldered to the original spring wire, which extended to the distal sides of the cuspids, by the application of which they also were moved forward. Another spring was then attached by solder to the original one, as before, to move the bicuspids forward, and at the same time one of the cuspids was prepared to be rotated by placing on it a collar, with a cylinder soldered to its palatal surface, to hold a spring which extended to the opposite side of the arch and hooked into the loop in the crib.

Fig. 7.—A cuspid or other tooth that is inside and a central or lateral outside of the line of the normal arch may at the same time be forced into line by constructing a crib for the back teeth on the same side of the arch as the teeth to be regulated, and from this crib extending forward the ends of the spring wire to the respective labial and lingual sides of the teeth which are to be moved.

FIG. 7.

FIG. 8.

Fig. 8 shows an appliance on a model for rotating a tooth. It is made like a crib, with the main wire following the outline of the gum as before described, and the ends left free to act as a spring on the labial and lingual surface of the tooth to be rotated, on which is placed a collar having slight depressions or sockets to receive the ends of the springs, which are curved to proper form to cause pressure in the desired direction, and conform to the surface of the gums. The appliance is easily made, can be used for any tooth, and does rapid work. The wide range of the action of these arms is peculiarly noticeable, for by them every conceivable direction may be given to the tooth according as one, or the other, or both of the arms shall be adjustably bent for action.

In uniting piano wires to form the crib, the joints are strengthened by first drawing the temper of the end of the wire, and flattening it very thin with the hammer, again drawing the temper and bending it around the main wire before soldering. If great strength is needed very thin copper wire should be wound about the joint before soldering. It is always well to make the parts bright and tin them before uniting, if soft solder is to be used. Use at all times a very weak solution of muriate of zinc, and preferably employ the soldering iron. Collars are indispensable in many cases for holding the ends of the spring in position on the teeth.

For the ordinary case a lug may project from the collar, but for special rotating purposes a socket is made, usually by soldering to the collar a loop of small platinum wire in suitable position to receive the end of the rotating spring.

If the crib is not well retained by the devices previously described, a separation should be made by wedging, to allow a cross wire to pass between the teeth to connect the sides of the crib, or a spring can extend from the crib to clasp a tooth in the same manner as for re-

the labial surface of the right inferior cuspid when the teeth were articulated measured about three-fourths of an inch (Fig. 9).

FIG. 9.

The superior maxilla was not, however, well developed, and the incisors needed to be made more prominent to assist in improving the outline of the features.

A split plate (Fig. 10) was made as described by Dr.

FIG. 10.

W. H. Coffin, of England, except that it did not cover the teeth or open the bite. It was strongly retained by two wire clasps extending from either side to clasp a bicuspid and molar. The plate was divided laterally, leaving the anterior part sufficiently large to cover the intermaxillary portion of the process for the purpose of forcing it forward with the teeth. Collars of gold, with lugs on their lingual surfaces, were placed on the incisors, and firmly retained the anterior part of the plate.

When the incisors were moved as far forward as practicable (Fig. 11, which shows the case after six months),

FIG. 11.

the appliance shown in Fig. 12 was made and adjusted, as seen in Fig. 13.

This metal appliance was made of brass to cover the

FIG 13.

taining a plate, or collars with slight ridges on their surfaces can be used as previously described.

I now present models and apparatus illustrating a procedure that proved efficient in correcting the position of the teeth in both the upper and lower maxillæ for a patient twenty-two years of age. The distance from the lingual surface of the right superior lateral to

chin, and provided with two perpendicular tubes soldered on the outer surface, and corresponding in position with the corners of the mouth. A crib was made of German silver wire, for the lower incisors and bicuspids, with the main wire on the labial surface and extending back, following the outline of the gum, to surround the bicuspids, with the wire ends left long to

act as springs on the lingual surface of the incisors. The crossbars to connect the sides of the crib extended over the grinding surface at the junction of the bicuspids on either side. The inferior first molars were at the outset pulpless, and were subsequently extracted. Wire posts were soldered to the main wire, and curved in suitable form to allow room for the action of the lower lip and to enter the tubes in the chin appliance at the proper angle. Two German silver wires were pivoted to the lower part of the chin apparatus, with the ends projecting upward and backward sufficiently far and diverging until they were about one and one-

FIG. 12.

half inches apart. The ends were then bent at sharp angles and united with solder. A metal button was soldered to each of these angles for the attachment of rubber bands, to exert the traction on the appliance. It is obvious that properly directed traction on the chin piece would force the crib backward, carrying all the inclosed lower incisors, cuspids, and bicuspids toward the second molars, which were finally almost touched by the bicuspids.

It will be noticed that the arch of the inferior oral teeth was maintained by the crib while in transit, and that the molars were in nowise disturbed. There is great advantage in having the wire portion pivoted to the appliance, as it acts like a whiffletree, and thus the appliance is not drawn sideways at each change of the tension. The part passing over the head was made of strong cord network, with a border of silk ribbon about one inch wide, to which were attached two nonelastic suspenders with buckles on either side. The buckles were provided with wire hooks, which were concealed by a flat piece of metal to receive the rubber bands.

The resulting improvement in the relations of the teeth is shown in Fig. 14, the impression for which illustration

FIG. 14.

lustration was taken six months after the application of the chin and crib apparatus.—*The Dental Cosmos.*

NEW VELVET PILE CRYSANTHEMUM.

IT was our privilege last year to present the first authentic figure of the novelty of the season, Mrs. Alpheus Hardy, and again we have the same good fortune, the figure subjoined being a lifelike representa-

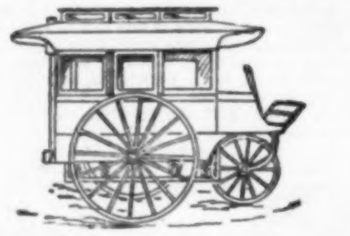
NEW VELVET PILE CHRYSANTHEMUM, LOUIS BOEHMER.

Color silvery pink, under sides of florets clothed with silvery hairs.

tion of a typical flower. It is a matter of much interest that this, like its predecessor of the velvet pile character, comes from America, being sent out by Messrs. Peter Henderson & Co., of New York, who made it known at the autumnal shows in the States last year, winning thereby golden honors. Very shortly the flower will speak for itself, but its first speech will be in a somewhat weak tone, for hard propagation will keep down the initial vigor, and we shall not see it in perfection until it has become established in the country. But then—well, we will wait and see what then; for the present here is the portrait of the candidate, and for a season at least it will be at the head of the poll.

TRICYCLE COACHES.

THE coming introduction of tricycle coaches on the streets has met with the hearty approval of a long



suffering public, whose hopes are now raised that the conveyances will be some relief from the present slow-going street cars. The promoters of the new enterprise have been running a sample of the new coaches for several weeks, with a view to testing its adaptation to their requirements. The coaches which are to be used here, however, will be twice the size of that, carrying sixteen passengers, while that carries but eight.—*Detroit Free Press.*

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